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Human Factors Assessment of Prototype Lightweight Thermal Undergarment Systems for the Clothe-the-Soldier Programme

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EXECUTIVE SUMMARY

INTRODUCTION

Because the thermal undergarment system currently in-service in the Canadian Forces (CF) has demonstrated a number of deficiencies since its inception in the 1960's, it is one of the clothing items identified for replacement as part of the Clothe-the-Soldier Programme.

Recent developments in fabric technology and garment design have led to significant improvements in the thermal protection, comfort, form, fit and bulk characteristics of commercially available thermal undergarments.

At the request of the Clothe-the-Soldier project team, this project evaluated several candidate commercial off-the-shelf (COTS) light-weight thermal undergarment (LWTU) systems according to human factors criteria, in order to facilitate the selection of a system for the Canadian Forces (CF).

Five LWTU test conditions and the in-service cold weather underwear were tested during field trials as six experimental conditions, the in-service condition representing the control. One unique LWTU test condition, of six test conditions, was issued to each of six groups of 32 personnel, totaling 192 subject participants. The LWTU conditions were issued during a fitting trial where anthropometric measurements of the participants were taken, and the participants were assessed for proper fit of the clothing. Initial fit and initial acceptance questionnaires were administered at the time of issue.

The individuals included in the trials were selected to be as representative as possible of the CF operational personnel. The mean weight of the subjects was heavier than the mean reported in the Anthropometric Survey of Canadian Forces Personnel (McCann et al., 1974). Initially, 208 individuals were included in the study, but only 114 completed all components of the study. This decreased number of participants resulted in as little as 16 individuals in some conditions, which reduces the power of the statistical analysis.

Findings of the Evaluation

Function

The in-service underwear was rated as significantly poorer in all functional aspects when compared with the LWTU test conditions. The best overall ratings for function were given for conditions D and E, although all of the LWTU test conditions were acceptable.

Suitability for Weather Elements

All of the LWTU test conditions were rated as acceptable for snow and rain. Only conditions D and E were considered acceptable in wind. The in-service underwear was rated below acceptable for all weather element types.

Comfort

All of the LWTU test conditions were considered largely acceptable for comfort and all were rated as significantly better than the in-service underwear. All LWTU test conditions were rated as acceptable for keeping the body dry and warm, and the feel of the material was considered acceptable for all of the test conditions. All other comfort ratings were between borderline and wholly acceptable, for all LWTU test conditions. Only the in-service underwear was rated unacceptable for all of the above comfort parameters. Type E did receive some minor complaints about chaffing at the thighs due to bagginess in the crotch area.

Durability

All conditions, including the in-service underwear were rated as acceptable for all aspects of overall durability. However, the in-service was rated less than acceptable for some specific aspects of the underwear. Many participants indicated that the LWTU test conditions did not appear to be robust enough, although slight wear was noted in only a few garments. Most agreed that this may be based on their perception, and not their experience.

Activities

The ratings for activities were all above largely acceptable for all of the LWTU test conditions. The in-service underwear was rated below borderline acceptability for high work loads. Some participants complained that bagginess in the crotch area (e.g. types A and E) interfered with some activities such as squatting and climbing.

Adjustability

The LWTU test conditions all were rated acceptable for adjustability, and most were rated higher than largely acceptable for most of the adjustments. The in-service underwear was rated the lowest for adjustability, sometimes receiving less than borderline acceptability ratings. Most participants felt that the LWTU test conditions were easy to doff and don, although a few suggested that slide fasteners (e.g. zippers) at the leg cuff would be helpful.

Compatibility With Other System Components

All of the conditions including the in-service underwear were rated as acceptable or better for compatibility with all system components. All of the LWTU conditions were rated as better than largely acceptable. Many participants did indicate that they did not use the fly since the outer layers of clothing usually made its use difficult. Most found it more convenient to pull all layers down at the same time. Female personnel must do this anyway, reinforcing the idea that a flyless unisex design may be acceptable.

Care of the Clothing

All of the LWTU test conditions were rated as largely acceptable for most aspects of care, while the in-service underwear was rated as largely unacceptable for most of the parameters.

Shrinkage was a minor problem for test conditions B and D. In fact both types also suffered significant static electricity buildup after being dried in a dryer.

Stowage

All of the LWTU test conditions were considered to be excellent in their ability to compress for storage. The light weight of the LWTU test conditions was also given as a positive attribute by most of the participants. In fact all of the LWTU test conditions were rated as almost wholly acceptable for all aspects of storage. In contrast, the in-service underwear was rated as unacceptable for some parameters and borderline for others.

Other Factors (Colour, Odour, Noise, Layering)

The majority of participants suggested that the LWTU should be either olive drab or black. The in-service underwear was the only type that received serious complaints about offensive odour, particularly after wear. Type A received some complaints about offensive odour after wear. There were no complaints about noise for any of the underwear types. All of the LWTU test conditions were rated very highly for their ability to allow layering of clothing.

Conclusions

The main conclusion of the evaluation is that any of the prototype conditions would be a suitable replacement for the in-service condition, for all aspects - function, durability, comfort, compatibility, stowage etc. However, two prototypes stand out from the rest.

- Condition E appears to be rated the highest in most categories, having only a few flaws, which should be considered in specifying requirements to the manufacturer. These improvements include crotch and seat design, waistband design and weight (although this parameter may be of less concern).
- The other prototype that offered promise was condition D. It too has some areas where improvement is required such as heat build-up during high workload and a longer drying time than the other prototypes.

Other conclusions from the evaluation include:

- that the ability of the material to pull moisture from the skin is very important - lack of this characteristic results in excessive loss of heat when sedentary
- the time in which the garment requires to dry must be short enough (15 to 30 minutes) to allow the wearer to vent the clothing for a short enough time, to dry, while not risking chilling
- the ability of the material to dry completely or partially even when not vented should be considered (only one prototype - B - appeared to have this characteristic)

- the ability to vent the garment at the neck was a feature mentioned by the majority of participants as useful - the slide fastener of condition D was considered ideal, but many suggested that the neck be a full turtle-neck rather than a mock turtle-neck of D
- condition E was rated very highly by the participants who used it
- condition E did require attention to improving the crotch and seat area, in order to reduce the bagging, sagging and bunching that occurs, and an improved waistband that is broader and less prone to stretching out of shape
- condition D was also rated highly but requires attention to improving the ability of the material to pull moisture from the surface of the skin (took longer to dry and left some participants wet after high workload activities)

ABSTRACT

The thermal undergarment system currently in-service in the Canadian Forces (CF) has demonstrated a number of deficiencies since being brought into service in the 1960's. It is one of the clothing items identified for replacement as part of the Clothe-the-Soldier Programme.

Recent developments in fabric technology and garment design have led to significant improvements in the thermal protection, comfort, form, fit and bulk characteristics of commercially available thermal undergarments.

This project evaluated several candidate light-weight thermal undergarment (LWTU) systems according to human factors criteria, in order to facilitate the selection of a system for the Canadian Forces (CF).

Five light-weight thermal underwear (LWTU) candidates (all available commercial off-the-shelf) and the in-service cold weather underwear, were tested during field trials as six experimental conditions (the in-service condition representing the control). One of the six LWTU conditions were issued to six different groups of 32 military personnel, totalling 192 subject participants. The LWTU were worn during sovereign exercises in Iqaluit and Churchill, between January and March 1997. Temperatures ranged from slightly above 0 °C to -68 °C (including wind chill). The LWTU was worn with standard issue winter clothing. The LWTU conditions were issued during a fitting trial where anthropometric measurements of the participants were taken, and the participants were assessed for proper fit of the clothing. Initial fit and initial acceptance questionnaires were administered at the time of issue.

Data on subjective thermal comfort were collected using a weekly questionnaire. An exit questionnaire was administered at the end of the trial period in conjunction with focus groups. The data were analyzed for comparative subjective ratings of each LWTU condition, examining comfort, function, fit, compatibility, care, and ease of doffing/donning. Specifications for the ideal LWTU set were developed from the findings of the trials.

It was concluded that two of the candidates appeared to best meet the requirements of the participants, although each had some areas where improvement was needed. It also was clear from the results that all of the prototypes were far superior to the in-service thermal underwear.

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1. INTRODUCTION

Because the thermal undergarment system currently in-service in the Canadian Forces (CF) has demonstrated a number of deficiencies since its inception in the 1960's, it is one of the clothing items identified for replacement as part of the Clothe-the-Soldier Programme.

Recent developments in fabric technology and garment design have led to significant improvements in the thermal protection, comfort, form, fit and bulk characteristics of commercially available thermal undergarments.

At the request of the Clothe-the-Soldier project team, this project evaluated several candidate commercial off-the-shelf (COTS) lightweight thermal undergarment (LWTU) systems according to human factors criteria, in order to facilitate the selection of a system for the Canadian Forces (CF).

1.1 Purpose

The purpose of this study was to collect reliable user feedback on the performance of COTS thermal undergarment systems, which use current product design, fabric and technology; as well as the in-service thermal undergarment. The main objectives of this work were to validate the Statement of Requirements for the thermal undergarment and to draft performance-based specifications for the procurement of a replacement LWTU.

1.2 Scope

Rhodes & Associates Inc. and the Defence and Civil Institute of Environmental Medicine (DCIEM) worked together to evaluate five COTS LWTU test conditions, compared with the present in-service cold-weather underwear. DCIEM conducted the initial fit trial (i.e., the anthropometry, sizing, initial fit questionnaire and initial acceptance questionnaire. All data entry was completed, electronically, by DCIEM using a scanner-based system.

This contracted project included the following components:

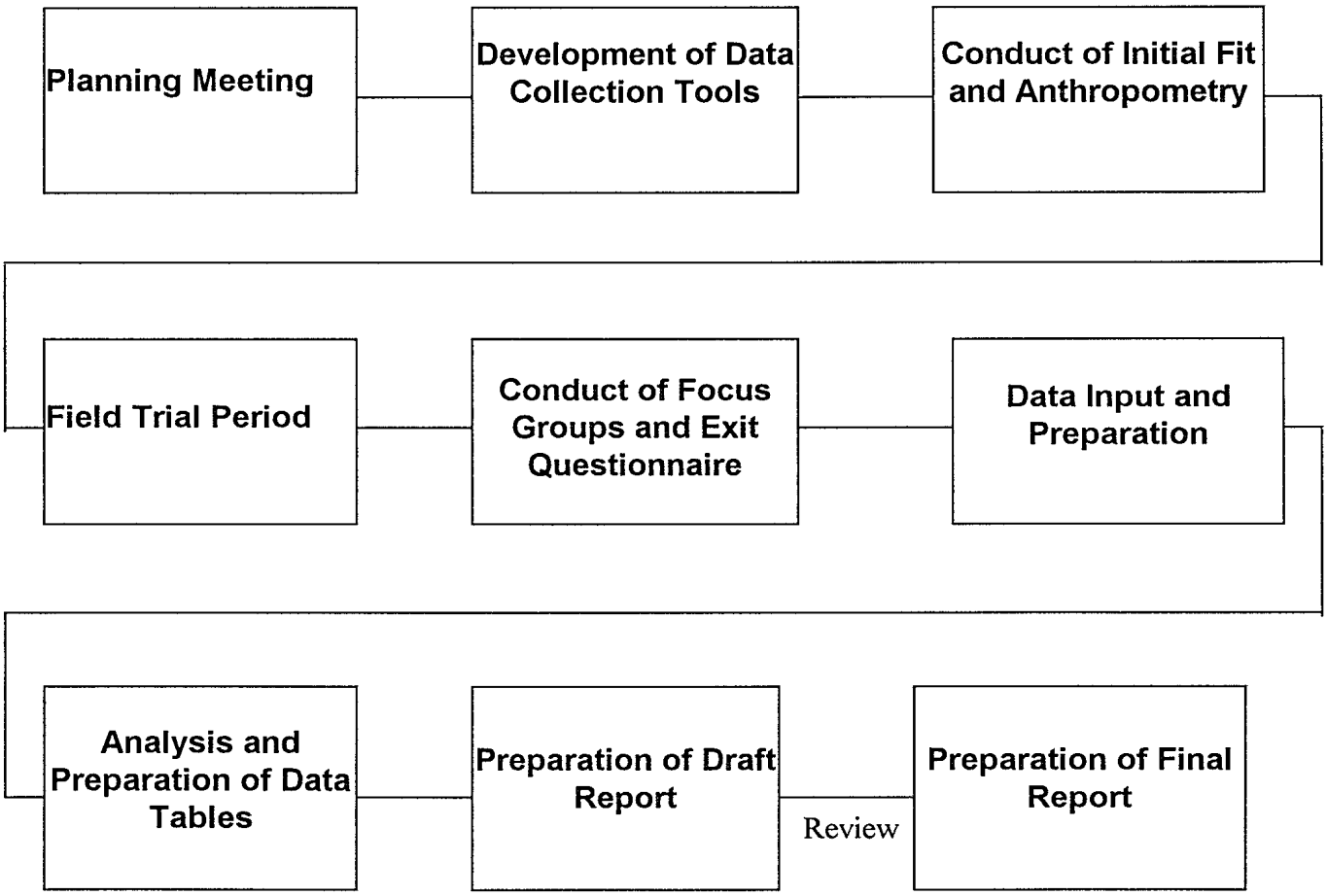
- initial planning meeting;
- developing an exit questionnaire;

- conducting focus groups and administering the exit questionnaire;
- analysing data from initial fit questionnaire, initial acceptance questionnaire, anthropometric measures, weekly thermal comfort questionnaires, exit questionnaire, and the focus group sessions; and
- preparing a report of trial findings and specifications for LWTU system.

1.3 Overall Approach

Figure 1-1 illustrates the general approach for the project.

Figure 1-1: General Approach



2. METHODOLOGY

This chapter provides a description of the methodology used in the human factors evaluation of the five LWTU systems.

The evaluation consisted of three phases: initial fit trial, on-exercise data collection, and follow-up data collection. In order to minimize project costs, DCIEM researchers completed all but the final phase of data collection. Rhodes & Associates Incorporated completed the final collection of data. The study was an independent, between subjects, evaluation of six different conditions of light weight thermal underwear.

2.1 Conditions of Use and Exposure Experience

The participants wore their assigned LWTU condition while involved in training missions that exposed them to extreme cold and precipitation in actual field conditions. The field training took place over a 6-week period, two weeks in Garrison, two weeks on winter warfare exercises at the base, and 10 days to two weeks on field exercises at Churchill, or Iqaluit located in the Arctic. The weather conditions for the field exercise period were variable, with temperatures ranging, on average, from a high of -21^0 C, to a low of -57^0 C, including wind-chill. It was not possible to trial the LWTU conditions with the new Improved Environmental Clothing System (IECS), Participants, therefore, wore their assigned LWTU condition with their in-service clothing and equipment.

2.2 Thermal Undergarment Conditions

Six thermal undergarment conditions were evaluated in the trial. These conditions are labeled A through F. The in-service thermal undergarment was included as the control condition, condition F. The five prototype LWTU systems were labeled as conditions A through E. All six systems consisted of a separate top and bottoms. Table 2-1 presents a brief description of the thermal undergarment conditions. Garment characteristics for conditions E and F were not provided.

Table 2-1. Description of Thermal Undergarment Conditions.

Characteristic	LWTU Condition					Control Condition
	A	B	C	D	E	F
Colour	Black	Blue	Blue	Blue	Black (some white examples as well)	Olive drab
Material	96% Thermax, 4% Lycra	100% Thermastat Polyester	Outer - 85% Wool, 15% Polyester; Inner - 100% Thermax	100% Wool	100% Polyester	100% cotton
Sizes	S, M, L, XL	S, M, L, XL	S, M, L, XL	S, M, L, XL	S, M, L, XL	S, M, L, XL
Style	men's top combined with women's bottom #1a	men's	men's/unisex	men's/unisex	men's/unisex	men's
Weight per set	Top: 200g Bottom: 180g	Top: 180g Bottom: 160g	Top: 200g Bottom: 180g	Top: 260g Bottom: 240g	Top: 240g Bottom: 400g	Top: 360g Bottom: 320g
Neck Design	crew, wide band, large opening	crew, narrow band, extra-large opening	crew, wide band, medium opening	Crew, medium opening	Mock turtleneck with slide fastener	Crew, wide band, large opening
Bottom Waist Design	add-on elastic 1 "	rolled, covered elastic 1"	add-on elastic 3/4 "	add-on elastic enclosed in casing 1/2 "	add-on elastic	add-on elastic
Bottom Crotch Length	11.5"	13.5"	11.5"	15"		

2.3 Trial Participants

Participants for the thermal undergarment evaluation were mainly drawn from two units at CFB Gagetown, New Brunswick, who were scheduled to participate in an Arctic exercise: an infantry unit -- 2RCR, and a field engineering unit -- 4ESR. Some militia personnel joined these two units for the field training. These militia personnel were included in the first two phases of the trial, but were unavailable for the final data collection phase. The Gagetown Test and Evaluation Unit trials staff, and researchers at DCIEM handled the sampling of CF personnel, for the thermal undergarment trial. Participants were asked to report their usual commercial underwear size (S, M, L, and XL). Participants were assigned to each condition based on these reports, ensuring as equal a distribution of sizes and rank by condition as possible.

2.4 Data Collection Phases

Data collection for the thermal undergarment evaluation was divided into two phases -- initial fit trial, and exit questionnaire/focus group sessions. The methodology employed for each of these phases is described in the following sections.

2.4.1 Initial Fit Trial

The fit trial was conducted on two days[1] -- January 10, 1997 and January 13, 1997. Participants were received from the 4ESR unit on the first day and from the 2RCR unit on the second day. The initial fit trial included the following eight activities.

1. The participants were briefed on the purpose and conduct of the fit trial. This briefing included general instructions to minimize bias and control sources of error, a demonstration of each underwear type, all anthropometric measurement, and specific instructions for completing the initial fit and initial acceptance questionnaires. Participants were told to launder their LWTU as they would their combat clothing (label instructions were removed). They were asked to keep track of their laundering methods and frequency.
2. Personal information (i.e., service number, unit, rank, surname, gender and age) was collected from each participant.
3. Eleven anthropometric measurements -- height, weight, neck girth, chest girth, girth at clothing waist band, buttock girth, scye girth, waist height, crotch height, sleeve inseam and sleeve length from spine to wrist -- were completed on each participant. The procedures documented in the *1988 Anthropometric Survey of U.S. Army Personnel: Methods and Summary Statistics* (Gordon, Churchill, Clauser, Bradtmiller, McConville, Tebbetts & Walker, 1989) were employed for all but two of these measurements, namely sleeve inseam length and waist girth. Reference information for the ANSUR procedures is provided below in Table 2-2. The procedure used for measurement of sleeve inseam length is documented in Appendix C, Table C31, of the *1974 Anthropometric Survey of Canadian Forces Personnel* (McCann, Noy, Rodden & Logan, 1975). For waist girth, the girth at which soldiers reportedly wore their waist-belt, was taken following a procedure described for the other torso girth measurements.
4. Each trial participant was assigned a thermal undergarment condition. For sizing, participants were requested to try on, in addition to their reported size, one size smaller and one size larger than the size they reported they would normally wear in a thermal undergarment top and bottom, and then select the size of each item that they felt fit them best.
5. Each participant was issued 2 pairs of LWTU (one condition only).

[1] A number of CF personnel were unavailable on these dates -- they completed the initial fit trial components at a later date, under the supervision of Test and Evaluation staff.

6. While wearing their assigned LWTU, each participant was asked to perform a number of range-of-motion exercises including: full neck rotation, shoulder-upper arm movement, shoulder reach, body rotation to the back, crouching, forward lunge with back leg supported at waist height, touching toes with legs kept straight (see Appendix E for pictorial diagrams of these movements).
7. The trial participants completed initial fit questionnaires, which gathered subjective data on the fit (on issue) of the thermal undergarment top and bottom. This questionnaire consisted of sixteen questions -- nine related to the fit of the top and seven related to the fit of the bottoms. The initial fit questionnaire is presented in Appendix A.
8. The participants completed initial acceptance questionnaires which gathered subjective information on the initial impressions of the participants regarding garment design, comfort, mobility, appearance, et cetera. The questionnaire consisted of fourteen questions, and is presented in Appendix A.

These eight activities completed the fit trial components of the thermal undergarment evaluation.

Table 2-2. Anthropometric Measurement Procedure Reference Information.

Thermal Undergarment Evaluation Measurement	ANSUR* Measurement Number	ANSUR* Procedure Page Ref.
Height	99	270
Weight	124	320
Neck Girth	80	232
Chest Girth	33	138
Waist Girth – modified 113 (see text in section 2.3.1., item 3)	113	N/A
Buttock Girth	23	118
Scye Girth	88	248
Waist Height - Omphalion	119	310
Crotch Height	38	148
Sleeve Length: Spine to Wrist	96	264
** ANSUR = 1988 Anthropometric Survey of U.S. Army Personnel*		

2.4.2 Exit Questionnaires and Focus Group Sessions

The second phase of the thermal undergarment evaluation consisted of collecting comprehensive performance information at the end of the wear period on each thermal undergarment condition.

This information was collected using questionnaires and by conducting focus groups (i.e., group discussion sessions) by LWTU condition. Rhodes and Associates Incorporated completed this final phase of the evaluation. The exit questionnaire and focus group sessions were completed over a two-week period from March 10, 1997 to March 19, 1997.

A final questionnaire -- exit questionnaire -- was developed for this phase of the trial. The fundamental structure of the questionnaire was based on a standard human factors questionnaire format provided by DCIEM. This standard questionnaire was refined for the thermal undergarment evaluation purposes by Rhodes & Associates Inc., in consultation with DCIEM. The resulting exit questionnaire was a nine-page item consisting of two sections, one for the thermal bottom and one for the thermal top. Each section addressed the same topics: conditions of wear; function, durability and comfort of specific features; activities; suitability; adjustment; comfort; durability; body waste elimination; care; compatibility; other issues, such as colour and noise; stowage; fit; and overall performance ratings. The exit questionnaire is presented in Appendix A.

Exit questionnaire completion took place over a two-week period at CFB Gagetown. During the first week personnel from the 4ESR unit were mainly involved, and during the second week personnel from the 2RCR unit were mainly involved. The exit questionnaires were completed with fairly small groups of approximately 10 to 12 participants who had worn the same thermal undergarment condition. Prior to questionnaire completion, each group of participants was given a brief (15 minute) presentation that covered the instructions for completing the questionnaire and incorporated a review of each page. The questionnaires required between 1 and 1.5 hours to complete.

Focus group sessions were conducted with the same condition-specific groups assembled for exit questionnaire completion. The focus group sessions were conducted in order to collect first-hand, detailed performance information on the thermal undergarment conditions. The focus group sessions were administered following completion of the exit questionnaire and a brief (15 minute) break. At the outset of each focus group session, the participants were briefed on the session procedures. More specifically, the focus group facilitators explained the following points.

- The focus group session was a facilitated group discussion regarding the performance of the thermal underwear, initiated by the contractor.
- The purpose of the session was to collect more detailed information on the performance of the thermal underwear, in order to better understand the reasons behind any positive or negative experiences or aspects of wear.
- The session touched on all performance aspects addressed in the exit questionnaire, but proceeded in a less structured format. Participants were encouraged to introduce any other relevant issues.
- Each participant's experiences in terms of the performance of the thermal underwear may have been quite different (depending on individual physiology, work rates, tasks

performed, environmental conditions experienced, clothing layers worn, individual comfort thresholds, et cetera). The participants were encouraged to inform the facilitators if their experiences with the thermal undergarment were similar to or different than, those reported by other participants. Participants were informed of the importance of each individual's experience, and that there were no "correct" answers.

The number of participants differed from the initial fitting and those who attended the focus group and exit questionnaire sessions. See Table 2-3 below for details.

Table 2-3. Number of Male Trial Participants per Data Collection Phase.
(edited data)

Data Collection Phase	Thermal Undergarment Condition						Total
	A	B	C	D	E	F	
Phase I:							
Initial Fit Trial	31	35	31	33	31	32	193
Initial Fit Questionnaire	35	37	36	33	32	30	203
Initial Acceptance Questionnaire	36	37	35	37	33	30	208
Exit Questionnaire	24	17	21	17	18	17	114
Phase III:							
Focus Group Session	25	16	20	18	16	21	116

2.5 Data Entry Procedures

Data entry for all questionnaires (initial fit, initial acceptance, weekly thermal comfort, and exit questionnaire) was completed using an automated scanning procedure, where the raw data file was scanned and then converted into a customized MS-Excel spreadsheet. The personal information, anthropometric data and size information was entered manually into an MS-Excel spreadsheet.

2.6 Data Analysis Procedures

All data analyses were completed using the *Number Cruncher Statistical System* (NCSS) (Hintze, 1995). MS Excel spreadsheet files were compiled and linked by the participant's service number, and then directly imported into NCSS for statistical analysis. The Kruskal-Wallis non-parametric one-way ANOVA was applied to the data, examining the differences between test conditions for each of the dependent scaled variables found in the questionnaires. The K-W model was chosen over the standard General Linear Model (GLM) since normality could not be assumed.

3. RESULTS & DISCUSSION

This chapter presents results from the three phases of the LWTU evaluation.

3.1 Data Quality

Data for the LWTU trial was collected on five separate forms (see Appendix A):

1. Anthropometric data forms -- personal history information, anthropometric measurements, self-selected size specifications.
2. Initial fit questionnaires -- initial fit responses – five-point scale ordinal data.
3. Initial acceptance questionnaires -- initial acceptance responses five-point scale ordinal data.
4. Exit questionnaires -- comprehensive performance information on thermal undergarments -- five-point scale ordinal data.

The data on the exit questionnaires were entered into spreadsheet format via an automated scanning process. These data entry activities were completed at DCIEM, by DCIEM staff. The data were provided in spreadsheet form, to Rhodes & Associates Inc., as more than 150 separate MS-Excel files. Processing of the data required that the files for each of five data collection forms (listed above) be merged, and re-coded into a format that would allow statistical processing. Following the merging and recoding procedures, the observations between the five separate files were verified for consistency with respect to the service number of participants and the assigned condition of thermal undergarment.

3.2 Trial Participants

The number of trial participants varied with each phase of data collection. All but two of the participants were male. The small number of females precludes any opportunity to properly separate out possible gender bias in the results. Hence, data for the two female participants were excluded from the analyses. Table 3-1 demonstrates the number of male participants for each phase of data collection for the thermal undergarment evaluation. A decrease in trial participants for the final data collection phase was anticipated, as the militia participants that were part of earlier phases, were no longer available. About 50% of the original participants completed the exit questionnaire and attended the focus groups. The increase in participant number between

anthropometric measurement and the initial fit, and acceptance questionnaire, is explained by the fact that a few participants missed the anthropometry session. The greater number of initial acceptance questionnaires is due to five individuals neglecting to complete the fit questionnaire.

Table 3-1. Number of Male Trial Participants per Data Collection Phase.

Data Collection Phase	Thermal Undergarment Condition						Total
	A	B	C	D	E	F	
Phase I:							
Anthropometric Measurements	31	35	31	33	31	32	193**
Initial Fit Questionnaire	35	37	36	33	32	30	203
Initial Acceptance Questionnaire	36	37	35	37	33	30	208
Phase II:							
Exit Questionnaire	24	17	21	17	18	17	114
Focus Group Session	25	16	20	18	16	21	116*

* The focus group data contains input from the two female participants who were dropped from the exit questionnaire portion of the analysis.

** The anthropometric measurements were taken for only those participants who attended the initial fit and acceptance sessions held in Gagetown during the week of March 10th. Some individuals completed the fit and acceptance questionnaires at a later date.

3.2.1 Distributions of Participants by Unit, Rank and Age

Separate distributions for the sample by unit (Table 3-2), rank (Table 3-3) and age (Table 3-4) were generated in order to ensure that each characteristic was fairly well represented across the thermal undergarment conditions. For the most part, these characteristics demonstrated fairly consistent representation across the conditions. The only notable exception was for condition F where the proportion of participants received from the 1RNBR unit was considerably higher than that apparent for the other conditions. There was also a notably higher percentage of Private and Corporal ranks for condition F, as well as a notably higher percentage of participants in the 20 to 24 year old age category, relative to the other conditions. The Test and Evaluation Unit at Gagetown arbitrarily assigned individuals to the each of the conditions.

The effect of these differences in distribution on the results is likely minimal, given that a primary interest is to identify and understand performance differences in the prototype thermal undergarments (i.e., conditions A through E). Considerable information regarding the shortcomings of the in-service undergarment already exists.

Table 3-2. Percentage of Participants Representing Various Units (n=193).

Unit	Thermal Undergarment Condition						Sample Total
	A (η=31)	B (η=35)	C (η=31)	D (η=33)	E (η=31)	F (η=32)	
2RCR	42%	46%	39%	39%	42%	34%	40%
4ESR	42	37	42	36	35	31	37
RCAS	10	6	10	12	10	13	10
1RNBR	6	0	0	3	3	16	5
8CH	0	3	3	3	10	3	4
3RCA	0	6	3	3	0	0	2
Other[2]	0	3	3	3	0	3	2

Table 3-3. Percentage of Participants Representing Various Ranks (n=193).

Unit	Thermal Undergarment Condition						Sample Total
	A (η=31)	B (η=35)	C (η=31)	D (η=33)	E (η=31)	F (η=32)	
Private	29%	31%	32%	33%	39%	41%	34%
Corporal	39	34	42	30	32	38	36
Master Corporal	13	14	10	18	13	13	13
Sergeant	6	11	6	9	10	6	8
Warrant Officer	3	3	0	0	6	3	3
Master Warrant Officer	0	0	3	3	0	0	1
Lieutenant	3	3	3	6	0	0	3
Captain	6	3	3	0	0	0	2

Table 3-4. Percentage of Participants Representing Various Age Categories (n=193).

Unit	Thermal Undergarment Condition						Sample Total
	A (η=31)	B (η=35)	C (η=31)	D (η=33)	E (η=31)	F (η=32)	
<19 years	3%	3%	6%	6%	3%	3%	4%
20 to 24 years	19	29	23	21	29	41	27
25 o 29 years	55	26	32	33	29	31	34
30 to 34 years	16	31	23	21	26	16	22
35 to 39 years	3	11	10	18	10	9	10
40 to 44 years	3	0	6	0	3	0	2

[2] Other Units include: 3FR, 3RCE, 403 SQN

3.3 Weather Conditions

The wear period for the trial spanned the months of January to March. Therefore, the trial participants during the pre-deployment exercises and on the field exercise experienced the extremes of the cold Canadian winter. Weather conditions varied a great deal during the wear period; temperatures ranging from slightly above 0 °C to -68 °C (including wind chill) were reported.

3.4 Anthropometric Measurements

Eleven anthropometric measurements were taken on the trial participants as part of the initial fit trial. These measurements were taken for the purposes of:

- assessing how representative the trial sample is relative to the body size range apparent in the total CF population;
- assessing differences between the thermal undergarment conditions in terms of the anthropometry of participants; and
- understanding individual sizing problems with the thermal undergarments.

3.4.1 LWTU Trial Sample versus CF Population

In order to address the first objective of the anthropometric measurement phase of the evaluation, descriptive statistics were generated for each of the eleven measures. These statistics are presented in Table 3-5.

The task of assessing how representative the thermal undergarment sample is relative to the CF population is somewhat hindered by the fact that current anthropometric data on the CF does not exist. In 1974 an anthropometric survey involving 32 measures on 565 male CF personnel was completed (McCann, Noy, Rodden & Logan, 1975). By comparing the height and weight summary statistics from the 1974 CF survey and the present sample measurements, differences between the two samples are evident (see Table 3-6 The LWTU participants are considerably heavier than the 1974 survey participants. While it is quite likely that the anthropometric characteristics of the CF population have changed over the past 20 years, it is highly unlikely that this change involves a mean weight increase of approximately 6.6 kg. Assuming that the 1974 sample was a random sample of the CF at the time, and that measurement equipment was properly calibrated and utilized for both the 1974 and current samples, it is evident that the LWTU sample was comprised of somewhat heavier males than of the total CF. Given that the LWTU sample was not a random sample of the CF population, but a sample derived from a specific population (e.g. engineering – where strength and size are an advantage), with major consideration of economic limitations and logistical necessity, these results are not surprising.

Also, it should be noted that the waist-girth measurement differed from the measurement used in the 1974 survey. It is not known how much of the difference for this dimension can be explained by the changed location of the measurement. It is simply important to note, in regards to the sizing and fit results, that the LWTU sample of participants were on average similar in height, but heavier and broader, than the majority of male CF personnel described in the 1974 survey.

Table 3-5. Summary Statistics for Anthropometric Measurements.

Statistic	Height (cm)	Weight (kg)	Neck Girth (cm)	Chest Girth (cm)	Waist Girth (cm)	Buttock Girth (cm)
η	193	192	191	192	192	193
Mean	175.7	83.4	38.7	102.9	88.6	99.0
SD	6.4	12.6	2.17	7.76	8.35	6.05
SEM	0.46	0.91	0.16	0.56	0.60	0.44
COV (%)	3.63	15.05	5.62	7.54	9.41	6.10
MIN	159.0	54.4	33.4	85.3	71.0	85.0
MAX	190.5	114.8	44.8	123.3	114.0	121.0
α_3	0.05	0.25	0.39	0.18	0.49	0.05
α_4	2.81	2.60	3.02	2.79	2.83	2.87

Statistic	Scye Girth (cm)	Waist Height (cm)	Crotch Height (cm)	Sleeve Inseam (cm)	Sleeve Length (cm)
η	191	184	190	192	193
Mean	46.1	105.5	82.5	44.9	87.7
SD	3.6	5.4	5.0	2.6	4.2
SEM	0.26	0.40	0.36	0.19	0.30
COV (%)	7.84	5.08	6.05	5.78	4.83
MIN	37.5	88.0	72.0	38.0	75.0
MAX	57.0	118.5	101.0	51.0	98.5
α_3	0.57	-0.07	0.16	0.00	-0.35
α_4	3.61	3.21	3.22	2.99	3.57

Table 3-6. Comparison of Height and Weight Summary Statistics between CF LWTU Trial Sample and 1974 CF Anthropometric Survey (McCann et al., 1975).

Statistic	LWTU Sample HEIGHT (cm)	1974 CF Survey HEIGHT (cm)	LWTU Sample WEIGHT (kg)	1974 CF Survey WEIGHT (kg)
Mean	175.7	175.0	83.6	77.0
SD	6.4	6.3	12.7	11.7
5th %'ile	164.5	164.8	64.3	59.4
50th %'ile	175.5	174.7	82.0	76.2
95th %'ile	188.0	185.2	105.8	95.7
η	193	565	193	565

3.4.2 Anthropometric Differences between Thermal Undergarment Conditions

The similarity in participant anthropometry across the six thermal undergarment conditions was assessed by completing a separate one-way general linear models (GLM) analysis of variance (ANOVA) for each measurement, with condition as the independent variable. This analysis demonstrated no statistically significant effect of condition on the mean anthropometric values across the six conditions (a significance level (α) of 0.05 was applied for all analyses). These results confirm that the anthropometry of participants was similar across the six thermal undergarment conditions.

3.5 Thermal Undergarment Size Distributions

Table 3-7. Distribution of Top and Bottom Sizes per Thermal Undergarment Condition.

Garment Size	Thermal Undergarment Condition					
	A (η=31)	B (η=35)	C (η=31)	D (η=33)	E (η=31)	F (η=32)
Top						
Extra-small	0%	0%	0%	0%	0%	0%
Small (women's)	0	0	0	0	3	0
Small	0	11	6	13	3	0
Medium	10	37	23	16	13	41
Large (women's)	0	0	0	0	0	0
Large	60	37	39	38	61	53
Extra-large	30	14	32	34	19	6
Bottom						
Extra-small	0%	0%	0%	0%	0%	0%
Small (women's)	0	0	0	0	3	0
Small	0	9	3	13	3	16
Medium	3	29	29	16	42	48
Large (women's)	20	0	0	0	0	0
Large	53	51	45	47	52	35
Extra-large	23	11	23	25	0	0

Distributions of sizes of thermal undergarments for each condition (male participants only) are presented in Table 3-7. The data forms for the initial fit trial indicated a lack of certain sizes for certain conditions at some point in the fitting process (e.g., large bottoms for condition E, and small top for condition B). In addition, some female sizes were indicated on the data forms for male participants, since the project required that a flyless underwear be tested (see Table 2-1 on page 4). The inclusion of women's type drawers (no fly), necessitated that the sizes chosen for the male participants be larger than they otherwise would. Details of the sizing systems for the conditions, (i.e., available sizes, sizing dimensions and size design ranges) were not provided. Comments in the following paragraph regarding the size distributions assume that four sizes were available per condition: small, medium, large and extra-large.

The C and D thermal undergarment conditions came from the same manufacturer and this may explain why the size distributions were quite similar for both the top and bottom of these two conditions. For both conditions A and E the top size choices appear too limited, with the majority of participants selecting the large size as best fitting. Similar conclusions can be drawn for condition F, as the majority of sizes were split between medium and large. Bottom sizing distributions for conditions A through D were quite similar, with the majority of subjects choosing the large size as best fitting, and the remainder split between the medium and extra-large sizes. Bottom sizing for conditions E and F seemed to provide a larger fit than the other

conditions, as participants were split between medium and large sizes, with no participants selecting the extra-large size.

3.6 Initial Fit Scores

The initial fit questionnaires asked for the participants' impressions of the fit of the thermal undergarment top and bottom in a number of areas, at the outset of the trial. A five-point rating scale was provided for response to each fit question - see Table 3-8 header. Mean ratings for the initial fit questions were calculated for all six conditions. These means are presented in Table 3-8. In order to determine whether or not the thermal undergarment worn had a significant effect on the initial fit parameters, a separate Kruskal-Wallis (K-W) test[3] was performed for each initial fit variable, with thermal undergarment condition as the grouping variable. When a significant effect due to thermal undergarment was observed, differences in the initial fit ratings between the conditions were assessed using the Kruskal-Wallis Z multiple comparison procedure. A 0.05 level of significance was used in all tests. The multiple comparison test results are also included in the table using superscript letters above the means -- means with the same superscript letter are *not* significantly different.

[3] The Kruskal-Wallis (K-W) test is a non-parametric test that can be used when F-test assumptions are violated. In terms of the thermal undergarment data, assumptions of distribution normality were violated for virtually all variables. The K-W test is also valid for variables where the measurement scale is, if not continuous, at least ordinal (Hintze, 1996).

Table 3-8. Mean Initial Fit Scores for Thermal Undergarment Conditions.

1	2	3	4	5
unacceptably small/short	slightly small/short but acceptable	good fit	slightly large/long but acceptable	unacceptably large/long

Fit Area	Thermal Undergarment Condition						
	A (η=35)	B (η=37)	C (η=36)	D (η=33)	E (η=32)	F (η=30)	All (η=203)
Top							
Neck Opening†	$3.3^{b,c}$	3.5^{c}	$2.9^{a,b}$	2.7^{a}	$3.1^{a,b,c}$	3.4^{c}	3.1
Sleeve Length	3.1	3.1	3.0	2.9	3.1	3.4	3.1
Sleeve Girth at Biceps	3.0	3.3	3.2	3.2	3.0	3.1	3.1
Wrist Cuff Girth	3.0	3.1	3.0	3.1	3.0	2.8	3.0
Armpit Shoulder Girth	3.0	3.2	3.1	3.1	2.9	3.0	3.0
Shirt Length†	$3.0^{a,b}$	$2.9^{a,b}$	$3.1^{a,b}$	$3.4^{b,c}$	2.6^{a}	3.6^{c}	3.1
Chest Girth	3.1	3.2	3.3	3.2	3.1	3.1	3.2
Waist Girth	3.1	3.3	3.2	3.3	3.1	3.4	3.2
Overall Fit	3.2	3.1	3.2	3.0	3.0	3.3	3.1
Bottom							
Waist Opening	3.3	3.0	3.2	3.3	3.4	3.3	3.2
Buttock/Hip Girth	3.3	3.0	3.0	3.2	3.3	3.3	3.2
Thigh Girth	3.0	2.8	2.8	2.9	3.0	3.1	2.9
Ankle Cuff Girth	3.0	3.1	2.9	2.8	3.0	2.6	2.9
Leg Length	3.4	3.1	3.3	3.2	3.2	3.3	3.2
Crotch Length†	3.6^{b}	3.1^{a}	3.0^{a}	$3.3^{a,b}$	3.7^{b}	$3.4^{a,b}$	3.3
Overall Fit	3.3	3.0	3.1	3.1	3.4	3.1	3.1

The statistical results presented in Table 3-8 show a significant effect of thermal undergarment condition on the initial fit responses related to the fit of the neck opening, shirt length and crotch length, although all are within the acceptable range. Therefore, it can be assumed that most of the participants found that their garment fit properly. It should be noted, however, that some individuals (less than 5%) did receive garments, which were the next size larger.

† significant effect of condition (α=0.05).

3.7 Initial Acceptance Scores

The initial acceptance questionnaire asked participants for their first impressions of various attributes of the thermal undergarment top and bottom. A five-point rating scale was provided for response to each question. Mean ratings for the initial acceptance questions were calculated for all six conditions. These means are presented in Table 3-9. The data was analysed using the same statistical tests described in Section 0, for the initial fit questionnaire responses.

Table 3-9. Mean Initial Acceptance Scores for Thermal Undergarment Conditions.

☹		😐		☺
1	2	3	4	5
completely unacceptable	largely unacceptable	borderline	largely acceptable	completely acceptable

Initial Acceptance Parameter	Thermal Undergarment Condition						
	A (η=36)	B (η=37)	C (η=35)	D (η=37)	E (η=33)	F (η=30)	All (η=208)
Top							
Design†	$3.7^{a,b}$	3.9^{a}	4.2^{a}	4.1^{a}	4.1^{a}	3.2^{b}	3.9
Ease of Donning	4.3	4.4	4.6	4.1	4.2	3.9	4.2
Ease of Doffing	4.2	4.2	4.4	4.3	4.1	3.9	4.2
Physical Comfort†	$3.9^{a,b}$	4.2^{b}	4.4^{b}	$4.1^{a,b}$	4.4^{b}	3.4^{a}	4.1
Range of Motion†	$4.3^{a,b}$	$4.3^{a,b}$	4.6^{b}	$4.3^{a,b}$	4.5^{b}	3.8^{a}	4.3
Bottom							
Design†	$3.7^{a,b}$	$4.0^{b,c}$	4.2^{c}	$4.1^{b,c}$	$3.9^{b,c}$	3.3^{a}	3.9
Ease of Donning	4.1	4.2	4.3	3.8	4.1	3.8	4.1
Ease of Doffing	4.1	4.1	4.2	3.8	4.0	3.6	4.0
Physical Comfort	3.9	4.1	4.3	4.1	4.1	3.4	4.0
Range of Motion	4.3	4.2	4.3	4.1	4.2	3.6	4.1
Complete Garment							
Appearance†	$4.2^{b,c}$	$3.7^{a,b}$	$4.2^{b,c}$	$4.1^{b,c}$	4.4^{c}	3.2^{a}	4.0
Durability†	$3.5^{a,b}$	3.3^{a}	$3.8^{a,b}$	$3.7^{a,b}$	4.0^{b}	$3.4^{a,b}$	3.6
Thermal Protection†	$3.3^{a,b,c}$	$3.2^{a,b}$	3.9^{c}	3.9^{c}	$3.8^{b,c}$	2.9^{a}	3.5

The statistical results presented in Table 3-9 indicate that the thermal undergarment condition had a significant effect on design, physical comfort, range of motion, appearance, durability and thermal protection. However, all LWTU test conditions, and the in-service underwear showed better than acceptable mean scores, except for thermal protection in the in-service underwear.

† significant effect of condition (α=0.05).

3.8 Exit Questionnaire Results

The exit questionnaire presented a total of 264 questions on the performance of the thermal undergarment. Approximately half of these questions were directed specifically at the performance of the undergarment bottom, and the other half were directed at the performance of the undergarment top. The most critical questions from the exit questionnaire were identified, and the data entered for these questions were edited. The data for the remaining questions were not edited due to a severe time limitation on the project. However, spot checking of the data for the unedited questions, indicated that less than 3% of the responses were in error. The tables of results for this section will indicate whether the summary statistics were calculated on edited or unedited data.

3.8.1 Conditions of Wear

The data collected from Section A of the thermal bottom exit questionnaire were requested in order to appreciate the participant's impressions of their frequency of exposure to various temperature ranges and their maximal exposure duration on any one occasion to the temperature ranges identified.

Participants were asked to indicate their frequency of exposure to four temperature ranges using a three point rating where: "1" was equated to a response of "never", "2" was equated to a response of "occasionally" and "3" was equated to a response of "frequently". The average frequency responses are presented in Table 3-10. These averages indicate that the trial participants most frequently experienced cold to extreme cold temperatures during the wear period.

Table 3-10. Average Frequency Score[4] for Thermal Undergarment Conditions.
(edited data)

Thermal Conditions	Thermal Undergarment Condition						Average per Thermal Condition
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	(η=113)
Cool (> 0 °C)	2.3	2.2	2.1	1.9	2.1	1.8	2.1
Cold (-15 °C to 0 °C)	2.5	2.5	2.6	2.5	2.7	2.3	2.5
Very Cold (-30 °C to -15 °C)	2.4	2.7	2.6	2.6	2.8	2.5	2.6
Extreme Cold (< -30 °C)	2.2	2.7	2.5	2.4	2.4	2.0	2.4

[4] Frequencies scored such that "1"=never, "2"=occasionally, and "3"=frequently.

Participants were asked to estimate their maximal uninterrupted exposure time to the four temperature ranges identified. Averages for these maximal times, for each temperature range, are presented in Table 3-11. These averages indicate that in the "worst case" scenarios, participants generally spent eight to nine hours at a time dealing with the winter elements during the wear period. It is noteworthy that participants often had difficulty interpreting this question. It is quite likely that the apparent differences between the conditions, in the maximal time worn responses, are a result of the presentation of the question and how it was interpreted.

Table 3-11. Average Maximal Time Worn (hours) for Thermal Undergarment Conditions.
(edited data)

Thermal Conditions	Condition						Average for All Conditions
	A	B	C	D	E	F	
Cool (> 0 °C)	9.3 (η=22)	9.4 (η=14)	10.9 (η=18)	6.2 (η=11)	7.5 (η=15)	6.9 (η=10)	8.7 (η=90)
Cold (-15 °C to 0 °C)	8.0 (η=24)	9.1 (η=17)	8.8 (η=20)	7.5 (η=17)	8.3 (η=17)	6.4 (η=14)	8.1 (η=109)
Very Cold (-30 °C to -15 °C)	8.9 (η=23)	9.2 (η=17)	10.1 (η=17)	10.3 (η=17)	8.7 (η=18)	8.1 (η=15)	9.2 (η=107)
Extreme Cold (< -30 °C)	6.9 (η=21)	9.6 (η=16)	11.3 (η=16)	7.4 (η=15)	7.4 (η=14)	7.5 (η=10)	8.4 (η=92)

3.8.2 Function of Specific Undergarment Features/Areas

Participants were asked to rate the function of various features and areas of the thermal undergarments, using a five-point rating scale. Average ratings per condition were calculated for each feature and area. Summary feature function ratings were derived for both the thermal undergarment bottom and top by averaging all function responses for each participant. Mean feature function ratings and mean summary ratings are presented in Table 3-12.

In order to determine whether or not the thermal undergarment worn had a significant effect on the function ratings, a separate K-W test was performed for each function parameter, with thermal undergarment condition as the grouping variable. When a significant effect due to thermal undergarment was observed, differences in the ratings between the conditions were assessed using the K-W Z multiple comparison procedure. A 0.05 level of significance was used in all tests. The multiple comparison test results are also included in the table using superscript letters above the means -- means with the same letter superscript are *not* significantly different.

The results for every feature/area are not discussed; only the most significant results from the function ratings for the thermal undergarment presented in Table 3-12 are summarized below.

Table 3-12. Mean *Function* Ratings per Thermal Undergarment Condition for Specific Garment Features and Areas.
(edited data)

☹		😐		☺
1	2	3	4	5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

Feature or Area	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=17)	All (η=114)
THERMAL BOTTOM							
Waist (NS)	4.4	3.9	4.0	4.2	3.6	3.3	3.9
Access Flap (Fly) (NS)	3.6	3.5	3.8	4.2	4.1	3.3	3.7
Hips/seat†	$3.9^{a,b}$	$4.2^{a,b}$	$4.1^{a,b}$	4.5^{b}	$4.1^{a,b}$	3.5^{a}	4.0
Crotch†	$3.5^{a,b}$	$3.8^{a,b}$	$3.9^{a,b}$	4.0^{b}	$3.3^{a,b}$	2.9^{a}	3.6
Thigh†	$4.1^{a,b}$	4.2^{b}	$4.2^{a,b}$	4.2^{b}	4.4^{b}	3.2^{a}	4.1
Knee†	$4.2^{a,b}$	$4.1^{a,b}$	$4.3^{a,b}$	4.6^{b}	4.5^{b}	3.4^{a}	4.2
Calf/Shin†	$4.1^{a,b}$	$4.2^{a,b}$	$4.2^{a,b}$	4.7^{b}	4.4^{b}	3.4^{a}	4.2
Cuff at Ankle†	$3.8^{a,b}$	$3.5^{a,b}$	4.3^{b}	4.4^{b}	4.3^{b}	2.8^{a}	3.9
All Seams†	3.9^{b}	4.2^{b}	4.1^{b}	4.4^{b}	4.4^{b}	2.8^{a}	4.0
Fabric†	$3.5^{a,b}$	$4.1^{b,c}$	$4.0^{b,c}$	$4.1^{b,c}$	4.7^{c}	2.5^{a}	3.8
Bottom – Function Summary†	$3.9^{a,b}$	4.0^{b}	4.1^{b}	4.3^{b}	4.2^{b}	3.1^{a}	3.9
THERMAL TOP							
Neck†	$3.3^{a,b}$	$3.2^{a,b}$	$3.6^{a,b}$	$3.8^{a,b}$	4.2^{b}	2.8^{a}	3.5
Shoulder†	$4.1^{a,b}$	4.4^{b}	4.3^{b}	4.5^{b}	4.4^{b}	3.4^{a}	4.2
Underarm†	$4.0^{a,b}$	4.4^{b}	4.2^{b}	4.4^{b}	4.3^{b}	3.1^{a}	4.1
Elbow†	4.2^{b}	4.4^{b}	4.2^{b}	4.6^{b}	4.3^{b}	3.3^{a}	4.2
Cuff at Wrist†	$3.9^{a,b}$	$3.4^{a,b}$	4.1^{b}	4.4^{b}	4.2^{b}	2.7^{a}	3.8
Bottom Edge†	4.0^{b}	$3.5^{a,b}$	3.9^{b}	4.3^{b}	4.1^{b}	2.2^{a}	3.7
All Seams†	$4.0^{a,b}$	4.2^{b}	4.2^{b}	4.5^{b}	4.4^{b}	3.2^{a}	4.1
Fabric†	$3.8^{a,b}$	4.2^{b}	$3.7^{a,b}$	4.4^{b}	4.3^{b}	2.5^{a}	3.8
Top -- Function Summary†	3.9^{b}	4.0^{b}	4.0^{b}	4.4^{b}	4.3^{b}	2.9^{a}	3.9

The overall mean function ratings for the thermal undergarment features ranged from 3.5 to 4.2 (far right column). The mean ratings for the crotch (3.6) and neck (3.5) were somewhat lower than the overall mean ratings for the other features. These two features were consistently commented on in the focus group sessions (refer to Section 3-9).

† significant effect of condition (α=0.05).

The results demonstrate a significant effect of thermal undergarment condition on all feature ratings except the waist and fly features. However, all mean ratings for the LWTU test conditions are close to largely acceptable. Only the in-service underwear was rated below or at borderline for most features.

3.8.3 Durability Ratings for Features/Areas

Table 3-13. Mean *Durability* Ratings per Thermal Undergarment Condition for Specific Garment Features or Areas.
(edited data)

☹		😐		☺
1	2	3	4	5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

Feature or Area	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=17)	All (η=114)
THERMAL BOTTOM							
Waist†	$4.2^{a,b}$	$4.1^{a,b}$	$4.2^{a,b}$	4.4^{b}	$4.1^{a,b}$	3.1^{a}	4.0
Access Flap (Fly) (NS)	4.2	3.9	4.2	4.5	4.2	3.6	4.1
Hips/seat†	$4.1^{a,b}$	$4.2^{a,b}$	$4.2^{a,b}$	4.5^{b}	$4.1^{a,b}$	3.4^{a}	4.1
Crotch†	$4.0^{a,b}$	4.4^{b}	$4.0^{a,b}$	4.4^{b}	$3.8^{a,b}$	3.4^{a}	4.0
Thigh†	$4.1^{a,b}$	4.3^{b}	4.2^{b}	$4.0^{a,b}$	4.4^{b}	3.1^{a}	4.1
Knee†	$4.1^{a,b}$	4.2^{b}	4.4^{b}	4.5^{b}	4.6^{b}	3.3^{a}	4.2
Calf/Shin†	$4.2^{a,b}$	$4.2^{a,b}$	$4.1^{a,b}$	4.6^{b}	4.7^{b}	3.4^{a}	4.2
Cuff at Ankle†	$3.8^{a,b}$	$3.4^{a,b}$	$4.0^{a,b}$	4.3^{b}	4.5^{b}	2.8^{a}	3.8
All Seams†	3.9^{b}	4.2^{b}	4.1^{b}	4.4^{b}	4.4^{b}	2.8^{a}	4.0
Fabric†	$4.0^{a,b}$	$4.0^{a,b}$	4.0^{b}	$4.0^{a,b}$	4.6^{b}	3.0^{a}	3.9
Bottom – Durability Summary†	4.0^{b}	4.1^{b}	4.2^{b}	4.3^{b}	4.3^{b}	3.2^{a}	4.0
THERMAL TOP							
Neck†	$3.9^{a,b}$	$3.6^{a,b}$	$4.0^{a,b}$	4.4^{b}	4.4^{b}	3.1^{a}	3.9
Shoulder†	4.3^{b}	4.4^{b}	4.3^{b}	4.5^{b}	4.4^{b}	3.4^{a}	4.2
Underarm†	$4.0^{a,b}$	4.2^{b}	4.2^{b}	4.6^{b}	4.4^{b}	3.1^{a}	4.1
Elbow†	$4.1^{a,b}$	4.4^{b}	4.4^{b}	4.5^{b}	4.3^{b}	3.2^{a}	4.2
Cuff at Wrist†	$3.9^{a,b}$	$3.5^{a,b}$	4.0^{b}	4.5^{b}	4.2^{b}	2.6^{a}	3.8
Bottom Edge†	4.0^{b}	$3.9^{a,b}$	$3.9^{a,b}$	4.4^{b}	4.2^{b}	2.8^{a}	3.9
All Seams†	$4.0^{a,b}$	4.2^{b}	4.2^{b}	4.4^{b}	4.3^{b}	3.2^{a}	4.1
Fabric†	$3.9^{a,b}$	4.1^{b}	4.2^{b}	4.2^{b}	4.5^{b}	2.8^{a}	4.0
Top – Durability Summary†	4.0^{b}	$4.0^{a,b}$	4.2^{b}	4.4^{b}	4.4^{b}	3.0^{a}	4.0

† significant effect of condition (α=0.05).

Table 3-13 shows the mean ratings for durability of the various features and areas of the garment conditions. All of the LWTU test conditions were rated as largely acceptable for all areas and features except for a very few cases for individual conditions for specific features. Nevertheless, these cases still rated as acceptable for durability. The in-service underwear was rated as unacceptable for various features and areas.

3.8.4 Comfort of Specific Undergarment Features/Areas

Table 3-14. Mean *Comfort* Ratings per Thermal Undergarment Condition for Specific Garment Features or Areas.

(edited data)

☹		😐		☺
1	2	3	4	5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

Feature or Area	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=17)	All (η=114)
THERMAL BOTTOM							
Waist (NS)	4.0	4.0	4.0	3.9	3.7	3.3	3.8
Access Flap (Fly) (NS)	3.9	3.8	4.2	4.3	4.1	3.6	4.0
Hips/seat†	$3.9^{a,b}$	$4.4^{a,b}$	$4.1^{a,b}$	4.6^{b}	$3.9^{a,b}$	3.4^{a}	4.1
Crotch†	3.4^{b}	4.1^{b}	3.9^{b}	3.9^{b}	3.4^{b}	2.9^{a}	3.6
Thigh	4.0	4.0	4.3	4.1	4.3	3.3	4.0
Knee†	$4.2^{a,b}$	$3.9^{a,b}$	4.4^{b}	4.6^{b}	4.5^{b}	3.4^{a}	4.2
Calf/Shin†	$4.0^{a,b}$	$3.9^{a,b}$	$3.9^{a,b}$	4.6^{b}	4.4^{b}	3.2^{a}	4.0
Cuff at Ankle†	4.1^{b}	$3.5^{a,b}$	$4.0^{a,b}$	4.2^{b}	4.4^{b}	2.8^{a}	3.8
All Seams†	4.1^{b}	4.2^{b}	4.2^{b}	4.6^{b}	4.5^{b}	2.9^{a}	4.1
Fabric†	$4.1^{a,b}$	$4.0^{a,b}$	4.3^{b}	$3.8^{a,b}$	4.8^{b}	2.9^{a}	4.0
Bottom -- Comfort Summary†	$4.0^{a,b}$	$4.0^{a,b}$	4.1^{b}	4.3^{b}	4.2^{b}	3.2^{a}	4.0
THERMAL TOP							
Neck (NS)	3.9	3.8	3.8	3.8	4.3	3.0	3.8
Shoulder†	$4.2^{a,b}$	4.4^{b}	$4.2^{a,b}$	$4.1^{a,b}$	4.5^{b}	3.3^{a}	4.1
Underarm†	$4.1^{a,b}$	$4.2^{a,b}$	4.2^{b}	$3.9^{a,b}$	4.4^{b}	2.9^{a}	4.0
Elbow†	4.3^{b}	4.4^{b}	$4.2^{a,b}$	$4.2^{a,b}$	4.4^{b}	3.4^{a}	4.2
Cuff at Wrist†	4.0^{b}	$3.6^{a,b}$	$4.0^{a,b}$	4.4^{b}	4.4^{b}	2.8^{a}	3.9
Bottom Edge†	4.2^{b}	$3.6^{a,b}$	$4.0^{a,b}$	4.3^{b}	4.1^{b}	2.7^{a}	3.8
All Seams†	$4.2^{a,b}$	$4.3^{a,b}$	$4.1^{a,b}$	4.4^{b}	4.5^{b}	3.4^{a}	4.1
Fabric†	$4.1^{a,b}$	$4.2^{a,b}$	4.3^{b}	$4.0^{a,b}$	4.5^{b}	3.2^{a}	4.1
Top -- Comfort Summary†	4.1^{b}	$4.1^{a,b}$	4.1^{b}	4.2^{b}	4.4^{b}	3.1^{a}	4.0

Participants were asked to rate the comfort of various features and areas of the thermal undergarments, using a five-point rating scale. Average ratings per condition were calculated

† significant effect of condition (α=0.05).

for each feature and area. Summary feature comfort ratings were generated for both the thermal undergarment bottom and top by averaging all comfort responses for each participant. Mean feature comfort ratings and mean summary ratings are presented in Table 3-14. The ratings were analysed using the same statistical tests described in Section 3-1.

The overall mean comfort ratings for the thermal undergarment features/areas ranged from 3.6 to 4.2 (far right column). The lowest comfort area ratings were received for the crotch (overall mean of 3.6). All of the LWTU test conditions were rated as mostly largely acceptable for most of the features and areas. Notable exceptions were the wrist and ankle cuffs on Type B, which were still acceptable but rated significantly lower than the other LWTU conditions. The in-service was unacceptable for many features and areas, and borderline for the balance.

3.8.5 Suitability Ratings for Thermal Undergarment Conditions

Table 3-15. Mean Temperature Suitability Ratings for Thermal Undergarment Conditions.
(edited data)

☹		☺		☺
1	2	3	4	5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM							
Extreme Cold (< -30 °C) †	2.4^{a}	$3.3^{a,b}$	$3.0^{a,b}$	4.1^{b}	4.3^{b}	2.0^{a}	3.1
Very Cold (-30 °C to -15 °C) †	3.1^{a}	$3.6^{a,b}$	$3.6^{a,b}$	4.3^{b}	4.4^{b}	2.4^{a}	3.5
Cold (-15 °C to 0 °C) †	$3.7^{a,b}$	$3.9^{a,b}$	4.1^{b}	4.4^{b}	4.4^{b}	2.7^{a}	3.9
Cool (0 °C to 10 °C) (NS	3.8	4.0	3.7	3.3	3.3	2.7	3.5
Bottom Summary Rating†	$3.2^{a,b}$	$3.7^{b,c}$	$3.6^{a,b,c}$	$4.0^{b,c}$	4.1^{c}	2.5^{a}	3.5
THERMAL TOP							
Extreme Cold (< -30 °C) †	$2.5^{a,b}$	$3.3^{a,b,c}$	$3.3^{a,b,c}$	4.2^{c}	$3.6^{b,c}$	1.8^{a}	3.1
Very Cold (-30 °C to -15 °C) †	$3.0^{a,b}$	$3.5^{a,b,c}$	$3.8^{b,c}$	4.4^{c}	4.2^{c}	2.4^{a}	3.5
Cold (-15 °C to 0 °C) †	$3.7^{a,b}$	$3.9^{a,b}$	4.0^{b}	4.5^{b}	4.5^{b}	2.7^{a}	3.9
Cool (0 °C to 10 °C) (NS	3.8	3.8	3.7	3.3	4.0	3.0	3.6
Top Summary Rating†	$3.2^{a,b}$	$3.6^{a,b}$	3.7^{b}	4.1^{b}	4.1^{b}	2.5^{a}	3.5

Participants were asked to provide separate ratings for the thermal undergarment top and bottom in terms of its suitability to: four temperature ranges, three weather elements, and three physical workloads. Average suitability ratings per condition were calculated for each

† significant effect of condition (α=0.05).

parameter. Summary suitability ratings for all three categories were generated for both the thermal undergarment bottom and top by averaging all relevant responses for each participant. Mean suitability parameter ratings and mean summary suitability ratings are presented in Tables 3-15 to 3-17. The ratings were analysed using the same statistical tests described in Section 3-1, for the feature function results.

The overall mean temperature suitability ratings (Table 3-15) for the thermal undergarments were almost identical for the top and bottoms. The ratings ranged from 3.1 to 3.9 (far right column) for both the top and the bottoms. Overall, participants found the thermal undergarments least suitable for extreme temperatures, and most suitable for cold temperatures[1]. The results demonstrate a significant effect of thermal undergarment condition on all temperature suitability ratings except those for the cool temperature range.

3.8.5.1 Summary of Results for Weather "Element" Suitability Ratings

Table 3-16. Mean Weather "Element" Suitability Ratings for Thermal Undergarment Conditions.
(edited data)

☹		☺		☺
1	2	3	4	5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM:							
Wind†	2.5^{a}	$2.8^{a,b}$	$2.7^{a,b}$	$3.6^{b,c}$	4.0^{c}	2.4^{a}	3.0
Snow†	$3.6^{a,b}$	$3.9^{a,b}$	4.1^{b}	4.2^{b}	4.3^{b}	2.8^{a}	3.8
Rain†	$3.1^{a,b}$	3.5^{b}	3.2^{b}	3.3^{b}	$2.7^{a,b}$	1.7^{a}	2.9
Bottom Summary Rating†	$3.0^{a,b}$	$3.4^{a,b,c}$	$3.4^{a,b,c}$	$3.8^{b,c}$	4.0^{c}	2.4^{a}	3.3
THERMAL TOP							
Wind†	2.8^{a}	2.6^{a}	$3.0^{a,b}$	4.0^{b}	4.1^{b}	2.4^{a}	3.1
Snow†	$3.5^{a,b}$	$3.5^{a,b,c}$	$4.0^{b,c}$	$4.3^{b,c}$	4.4^{c}	2.9^{a}	3.8
Rain†	3.3^{b}	3.3^{b}	3.5^{b}	3.7^{b}	3.8^{b}	1.7^{a}	3.1
Top Summary Rating†	$3.2^{a,b}$	$3.2^{a,b}$	$3.5^{b,c}$	$4.0^{b,c}$	4.2^{c}	2.4^{a}	3.4

[1] *The LWTU was worn with the in-service clothing system and not the IECS which was not available for the trial.*

† significant effect of condition (α=0.05).

Table 3-16 contains the mean ratings for the weather element suitability. The overall mean "element" suitability ratings for the thermal undergarments were very similar for the top and bottoms. The ratings ranged from 2.9 to 3.8 for the bottoms, and from 3.1 to 3.8 for the top (far right column). Overall, participants found the thermal undergarments least suitable for the rain and the wind, and most suitable for the snow. The results demonstrated a significant effect of thermal undergarment condition on all "element" suitability ratings.

3.8.5.2 Summary of Results for Physical Workload Suitability Ratings

Table 3-17 contains the mean scores for physical workload suitability. The thermal undergarment bottoms seemed generally better suited to low and medium workloads than high workloads -- ratings ranged from 3.3 for high workload to 3.9 for low workload. The top also seemed better suited for low physical workloads; the overall top ratings ranged from 3.4 for medium workload to 3.8 for low workload (no high workload rating was solicited from participants for the top -- an oversight on the exit questionnaires). The results demonstrated a significant effect of thermal undergarment condition on all physical workload suitability ratings.

Table 3-17. Mean Physical Workload Suitability Ratings for Thermal Undergarment Conditions.
(edited data)

☹ 1 wholly unacceptable	2 largely unacceptable	😐 3 borderline	4 largely acceptable	☺ 5 wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM							
Low Workload†	$3.6^{a,b}$	$4.0^{a,b}$	$3.9^{a,b}$	$4.2^{a,b}$	4.5^{b}	3.3^{a}	3.9
Medium Workload†	3.8^{b}	4.2^{b}	3.9^{b}	3.9^{b}	4.2^{b}	2.6^{a}	3.8
High Workload†	$3.3^{a,b}$	4.1^{b}	3.4^{b}	$3.4^{a,b}$	3.7^{b}	2.0^{a}	3.3
Bottom Summary Rating†	$3.6^{a,b}$	4.1^{b}	3.7^{b}	3.8^{b}	4.1^{b}	2.6^{a}	3.7
THERMAL TOP							
Low Workload†	$3.7^{a,b}$	$3.8^{a,b}$	$3.8^{a,b}$	4.1^{b}	4.5^{b}	2.6^{a}	3.8
Medium Workload†	$3.2^{a,b}$	3.9^{b}	3.4^{b}	3.6^{b}	3.9^{b}	2.1^{a}	3.4
Top Summary Rating†	$3.4^{a,b}$	3.9^{b}	$3.6^{a,b}$	3.9^{b}	4.2^{b}	2.4^{a}	3.6

† significant effect of condition (α=0.05).

3.8.6 Comfort Ratings for Thermal Undergarment Conditions

Participants were asked to provide separate ratings for the thermal undergarment top and bottom in terms of the comfort provided by the undergarment in: keeping the skin dry, keeping the body warm and the "feel" of the material. Average comfort ratings per condition were calculated for each of these categories. A summary comfort rating for was generated for both the thermal undergarment bottom and top by averaging all relevant responses for each participant. Mean comfort ratings and mean summary comfort ratings are presented in Table 3-18. The ratings were analysed using the same statistical tests described in Section 3-1, for the feature function results.

3.8.6.1 Summary of Results for Overall Comfort Ratings

Table 3-18. Mean Comfort Ratings for Thermal Undergarment Conditions.
(edited data)

☹		☺		☺
1	2	3	4	5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM							
Keeps Skin Dry†	3.8^{b}	4.4^{b}	3.8^{b}	4.4^{b}	4.2^{b}	1.6^{a}	3.7
Keeps Body Warm†	$3.2^{a,b}$	$3.4^{a,b,c}$	$3.6^{a,b,c}$	$4.3^{b,c}$	4.3^{c}	2.3^{a}	3.5
"Feel" of Material†	$4.1^{a,b}$	$3.9^{a,b}$	$4.0^{a,b}$	$3.8^{a,b}$	4.5^{b}	3.1^{a}	3.9
Summary Comfort Rating for Bottom†	3.7^{b}	3.9^{b}	3.8^{b}	4.2^{b}	4.4^{b}	2.4^{a}	3.7
THERMAL TOP							
Keeps Skin Dry†	3.8^{b}	4.4^{b}	4.0^{b}	4.4^{b}	4.4^{b}	1.6^{a}	3.8
Keeps Body Warm†	$3.4^{a,b}$	$3.6^{a,b}$	3.7^{b}	4.3^{b}	4.2^{b}	2.3^{a}	3.6
"Feel" of Material†	$4.2^{a,b}$	$4.1^{a,b}$	4.3^{b}	$4.0^{a,b}$	4.7^{b}	3.5^{a}	4.1
Summary Comfort Rating for Top†	3.8^{b}	4.0^{b}	4.0^{b}	4.2^{b}	4.4^{b}	2.5^{a}	3.8

The mean comfort ratings are contained in Table 3-18 above. The overall mean comfort ratings for the LWTU test conditions thermal undergarments were very similar for the top and bottoms. The ratings ranged from 3.5 to 3.9 for the bottoms and from 3.6 to 4.1 for the top (far right column). Overall, participants rated the thermal undergarment top and bottoms similarly across

† significant effect of condition (α=0.05).

the three comfort parameters, except for the in-service underwear, which was rated very low for comfort. The difference between the results for the in-service underwear and the other test conditions was significant.

3.8.7 Activity Summary Ratings for Thermal Undergarment Conditions

Table 3-19. Mean Activity Summary Ratings for the Thermal Undergarment Conditions. (unedited data)

☹ 1	2	3	4	☺ 5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM							
Low movement†[5]	4.0[b]	4.2[b]	4.1[b]	4.5[b]	4.4[b]	3.1[a]	4.1
High movement†[6]	4.0[b]	4.2[b]	4.1[b]	4.3[b]	4.2[b]	2.8[a]	4.0
Winter field living†[7]	4.1[b]	4.2[b]	4.0[a,b]	4.4[b]	4.2[b]	3.0[a]	4.0
Vehicle related†[8]	4.1[a,b]	4.1[a,b]	4.2[b]	4.5[b]	4.5[b]	3.2[a]	4.1
THERMAL TOP							
Low movement†	4.1[b]	4.0[a,b]	4.1[b]	4.4[b]	4.2[b]	3.1[a]	4.0
High movement†	4.0[b]	4.1[b]	4.1[b]	4.3[b]	4.0[b]	2.7[a]	3.9
Winter field living†	4.0[b]	4.2[b]	4.1[b]	4.5[b]	4.1[a,b]	2.9[a]	4.0
Vehicle related†	4.2[b]	4.2[a,b]	4.3[b]	4.4[b]	4.4[b]	3.2[a]	4.1

Participants were asked to provide separate ratings for the ease in performing 25 different activities while wearing the thermal undergarment top and bottom. For data reduction purposed, the 25 activities were divided in four groups and mean activity summary ratings for each participant were calculated for each of these groups. One group of activities was labeled low movement activities; this group included ratings for: sitting, standing, lying prone, sentry duties and stove watch. A second group of activities was labeled high movement activities; this group included ratings for: bending crouching, crawling, climbing, marching, running, skiing,

† significant effect of condition (α=0.05).

[5] the activities used to derive the summary ratings for this category were: sitting, standing, lying prone, sentry duties, and stove watch.

[6] the activities used to derive the summary ratings for this category were: bending, crouching, crawling, climbing, marching, running, skiing, snow shoeing, and patrolling.

[7] the activities used to derive the summary ratings for this category were: digging, field living, erecting tents, firing weapons, constructing snow defences, and constructing snow shelters.

[8] the activities used to derive the summary ratings for this category were: driving over-snow vehicle, operating vehicles, entering vehicles, exiting vehicles, and maintaining vehicles.

snow shoeing and patrolling. A third group of activities was labeled winter field activities; this group included ratings for: digging, field living, erecting tents, firing weapons, constructing snow defences and constructing snow shelters. The fourth group of activities was labeled vehicle related activities; this group included ratings for: driving over-snow vehicle, operating vehicles, entering vehicles, exiting vehicles and maintaining vehicles. The mean activity summary ratings for these four activity groups are presented for the top and bottoms in Table 3-19. The ratings were analysed using the same statistical tests described in Section 3-1.

The activity summary rating results presented Table 3-19 demonstrated very consistent ratings across all activity groupings and between the top and bottom ratings. In most cases, the statistical analyses indicated that condition F was rated significantly worse than the other conditions, but that there were no significant differences in the summary ratings across the prototype conditions.

3.8.8 Adjustment Ratings for Thermal Undergarment Conditions

Table 3-20. Mean Adjustment Ratings for the Thermal Undergarment Conditions.
(unedited data)

☹		😐		☺
1	2	3	4	5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM							
Easy to put on†	$4.3^{a,b}$	$4.4^{a,b}$	4.3^{b}	4.5^{b}	$4.4^{a,b}$	3.5^{a}	4.2
Easy to take off (NS)	4.3	4.2	4.3	4.2	4.3	3.5	4.2
Stays in place when worn†	4.1^{b}	$3.6^{a,b}$	4.1^{b}	4.4^{b}	$3.8^{a,b}$	2.8^{a}	3.8
Conforms to body shape†	4.0^{b}	$3.9^{a,b}$	4.2^{b}	4.3^{b}	3.9^{b}	2.8^{a}	3.9
THERMAL TOP							
Easy to put on†	$4.3^{a,b}$	$4.3^{a,b}$	$4.3^{a,b}$	4.4^{b}	4.6^{b}	3.7^{a}	4.3
Easy to take off†	$4.3^{a,b}$	$4.4^{a,b}$	$4.2^{a,b}$	4.5^{b}	4.7^{b}	3.6^{a}	4.3
Stays in place when worn†	4.0^{b}	$3.6^{a,b}$	4.0^{b}	4.1^{b}	4.1^{b}	2.7^{a}	3.8
Conforms to body shape†	4.2^{b}	$3.8^{a,b}$	4.2^{b}	4.4^{b}	4.6^{b}	2.7^{a}	4.0

Participants were asked to rate the ease of donning and doffing the undergarment top and bottom, and they were asked to rate how well the garment stayed in place when worn and how

† significant effect of condition (α=0.05).

well it conformed to their body shape. Mean adjustment ratings for the top and bottom in each condition are presented in Table 3-20. The ratings were analysed using the same statistical tests described in Section 3-1.

The adjustment ratings were favourable, with the overall means ranging from 3.8 to 4.2 for the bottoms and from 3.8 to 4.3 for the top. There was a significant effect on the adjustment ratings due to the thermal undergarment for all adjustment parameters except ease of doffing the bottoms.

3.8.9 Miscellaneous Comfort Ratings for Thermal Undergarment Conditions

Table 3-21. Mean Miscellaneous Comfort Ratings for Thermal Undergarment Conditions.
(unedited data)

☹ 1	2	3	4	☺ 5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM							
Skin irritation†	$4.3^{a,b}$	$3.7^{a,b}$	$4.3^{a,b}$	$3.3^{a,b}$	4.4^{b}	3.1^{a}	3.9
Skin allergies (NS)	4.5	4.1	4.5	4.1	4.5	3.6	4.3
Pressure points (NS)	4.3	4.1	4.4	4.4	4.5	3.6	4.2
Overall short-term wear†	$4.0^{a,b}$	$4.1^{a,b}$	4.4^{b}	4.4^{b}	4.6^{b}	3.1^{a}	4.1
Overall long-term wear†	$3.4^{a,b}$	3.9^{b}	3.9^{b}	$3.6^{a,b}$	4.4^{b}	2.3^{a}	3.6
THERMAL TOP							
Skin irritation (NS)	4.1	4.2	4.2	3.4	4.2	3.3	3.9
Skin allergies (NS)	4.4	4.3	4.3	4.0	4.5	3.9	4.3
Pressure points (NS)	4.1	4.2	4.4	4.4	4.4	3.5	4.2
Overall short-term wear†	$4.1^{a,b}$	$4.2^{a,b}$	4.3^{b}	4.4^{b}	4.6^{b}	3.2^{a}	4.1
Overall long-term wear†	$3.6^{a,b}$	4.0^{b}	4.1^{b}	3.9^{b}	4.6^{b}	2.3^{a}	3.8

Participants were asked to rate the acceptability of the undergarment top and bottom in terms of the following comfort parameters: skin irritation (e.g., chafing), skin allergies (e.g., rash), pressure points, short-term wear, and long-term wear. Mean ratings for these miscellaneous

† significant effect of condition (α=0.05).

comfort parameters for the top and bottom in each condition are presented in Table 3-21. The ratings were analysed using the same statistical tests described in Section 3-1.

In terms of the entire sample, the comfort parameter ratings for the thermal undergarment bottoms ranged from 3.6 to 4.3, with acceptability in overall long-term wear receiving the least favourable ratings. The overall results for the thermal undergarment top were essentially the same as those for the bottoms. There was a significant effect on the comfort ratings due to the thermal undergarment for skin irritation in the bottoms, and short-and long-term wear for both the top and the bottoms.

3.8.10 Durability Ratings for Thermal Undergarment Conditions

Table 3-22. Mean Durability Ratings for Thermal Undergarment Conditions.
(unedited data)

☹		😐		☺
1	2	3	4	5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM							
Tears†	$4.1^{a,b}$	4.5^{b}	$4.2^{a,b}$	$4.2^{a,b}$	4.6^{b}	3.1^{a}	4.1
Wear†	$4.0^{a,b}$	4.5^{b}	$4.1^{a,b}$	$4.1^{a,b}$	$4.3^{a,b}$	3.5^{a}	4.1
Snagging†	$4.1^{a,b}$	4.5^{b}	$4.1^{a,b}$	$4.0^{a,b}$	4.3^{b}	3.4^{a}	4.1
Stitching†	$3.8^{a,b}$	4.7^{b}	4.3^{b}	4.4^{b}	4.3^{b}	3.1^{a}	4.1
Stains	4.3	4.6	4.5	4.5	4.4	4.0	4.4
Sagging/bagging†	3.8^{b}	$3.5^{a,b}$	3.9^{b}	4.2^{b}	$3.3^{a,b}$	2.4^{a}	3.5
Elastic at ankle cuff†	4.0^{b}	$3.5^{a,b}$	$4.0^{a,b}$	4.2^{b}	4.3^{b}	2.6^{a}	3.8
Elastic at waist	4.0	3.6	3.6	3.9	3.6	2.7	3.6
THERMAL TOP							
Tears†	$4.2^{a,b}$	$4.3^{a,b}$	$4.3^{a,b}$	4.4^{b}	$4.2^{a,b}$	3.4^{a}	4.1
Wear (NS)	4.0	4.1	4.2	4.4	4.3	3.5	4.1
Snagging (NS)	4.2	4.2	4.2	4.4	4.2	3.3	4.1
Stitching†	$4.0^{a,b}$	4.5^{b}	4.3^{b}	4.5^{b}	4.3^{b}	3.1^{a}	4.1
Stains (NS)	4.2	4.3	4.2	4.6	4.1	3.6	4.2
Material†	4.1^{b}	4.3^{b}	3.9^{b}	4.1^{b}	4.4^{b}	2.8^{a}	3.9
Elastic at wrist cuff†	3.7^{b}	$3.4^{a,b}$	$3.7^{a,b}$	4.1^{b}	4.2^{b}	2.4^{a}	3.6
Elastic at bottom edge†	3.8^{b}	3.8^{b}	3.5^{b}	4.1^{b}	3.9^{b}	2.0^{a}	3.5

† significant effect of condition (α=0.05).

Participants were asked to rate the acceptability of the undergarment top and bottom in terms of the following durability parameters: tears (i.e., actual separation of fabric), wear (i.e., thinning of fabric), snagging, stitching, stains, sagging/bagging, elastic at ankle cuff, elastic at waist, elastic at wrist cuff, elastic at bottom edge, and material. Mean ratings for these durability parameters for the top and bottom in each condition are presented in Table 3-22. The ratings were analysed using the same statistical tests described in Section 3-1.

In terms of the overall sample averages from Table 3-22, durability ratings were poorest for the bottoms in sagging/bagging, waist elastic and ankle cuff; and poorest for the top in bottom edge elastic, wrist cuff and material. Overall ratings for other durability parameters were reasonably acceptable. There was a significant effect on the durability ratings due to the thermal undergarment condition for the bottom in: tears, wear, snagging, stitching, sagging/bagging, and ankle cuff; and for the top in: tears, stitching, material, wrist cuff and bottom edge. There was no significant effect of condition on the durability ratings for the bottom in: staining or waist elastic; and for the top in: wear, snagging and staining.

3.8.11 Compatibility Ratings for Thermal Undergarment Conditions

Participants were asked to rate the acceptability of the undergarment top and bottom in terms of compatibility with other clothing items. Mean ratings for the compatibility items for the top and bottom in each condition are presented in Table 3-23. The ratings were analysed using the same statistical tests described in Section 3-1.

Compatibility ratings for all conditions except condition F were, on average, largely acceptable for the majority of clothing items listed. Overall, compatibility of conditions A, D and F with almost all items was quite high and generally rated significantly more favourably than the ratings for condition F.

Table 3-23. Mean Compatibility Ratings for Thermal Undergarment Conditions.
(unedited data)

☹		😐		☺
1	2	3	4	5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM							
Thermal top†	4.3^{b}	$4.2^{a,b}$	$4.1^{a,b}$	4.6^{b}	$4.1^{a,b}$	3.0^{a}	4.1
Combat trousers (NS)	4.2	4.5	4.2	4.2	4.2	3.3	4.1
Arctic trousers (NS)	4.5	4.4	3.8	4.3	4.4	3.4	4.1
Gortex socks	*(insufficient η)*						
Wool socks†	4.5^{b}	$4.2^{a,b}$	4.1^{b}	4.4^{b}	4.4^{b}	3.3^{a}	4.2
Boot liner†	4.6^{b}	$4.4^{a,b}$	$4.0^{a,b}$	$4.3^{a,b}$	4.5^{b}	3.1^{a}	4.2
Combat boot†	4.6^{b}	4.4^{b}	$3.9^{a,b}$	4.3^{b}	4.6^{b}	3.2^{a}	4.2
Arctic boot†	4.5^{b}	4.5^{b}	4.4^{b}	4.5^{b}	4.7^{b}	3.3^{a}	4.3
IECS - uninsulated pant	*(insufficient η)*						
IECS - insulated pant	*(insufficient η)*						
Fleece bottoms	*(insufficient η)*						
THERMAL TOP							
Thermal bottoms†	4.4^{b}	4.2^{b}	$3.9^{a,b}$	4.4^{b}	4.2^{b}	2.9^{a}	4.0
In-service winter shirt†	4.3^{b}	$3.7^{a,b}$	$3.9^{a,b}$	4.2^{b}	4.4^{b}	2.7^{a}	3.9
Combat jacket†	4.5^{b}	$4.0^{a,b}$	$4.1^{a,b}$	$4.4^{a,b}$	$4.3^{a,b}$	3.4^{a}	4.2
Arctic jacket†	4.4^{b}	$4.2^{a,b}$	$4.3^{a,b}$	4.4^{b}	4.6^{b}	3.4^{a}	4.2
Combat gloves†	4.5^{b}	$4.1^{a,b}$	$4.0^{a,b}$	$4.3^{a,b}$	4.4^{b}	3.2^{a}	4.1
Arctic gloves†	4.7^{b}	$4.1^{a,b}$	4.4^{b}	4.6^{b}	4.6^{b}	3.3^{a}	4.3
Arctic hood†	4.7^{b}	$4.3^{a,b}$	$4.4^{a,b}$	4.6^{b}	4.6^{b}	3.5^{a}	4.4
IECS - uninsulated jacket	*(insufficient η)*						
IECS - insulated jacket	*(insufficient η)*						

3.8.12 Garment Care Ratings for Thermal Undergarment Conditions

Participants were asked to provide separate ratings for care related issues of the thermal undergarment top and bottom. Participants were asked to rate the acceptability of shrinkage, washing ease, drying ease, ease of repairing the garment, et cetera. Mean garment care ratings

† significant effect of condition (α=0.05).

per condition were calculated for all care parameters, these means are presented Table 3-24. The ratings were analysed using the same statistical tests described in Section 3-1.

Table 3-24. Mean Garment Care Ratings for Thermal Undergarment Conditions.
(unedited data)

☹ 1 wholly unacceptable	2 largely unacceptable	😐 3 borderline	4 largely acceptable	☺ 5 wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM							
Shrinkage†	$4.2^{b,c}$	$3.9^{b,c}$	$4.2^{b,c}$	$3.2^{a,b}$	4.4^{c}	1.6^{a}	3.7
Washing†	4.2^{b}	4.5^{b}	4.5^{b}	4.2^{b}	4.7^{b}	2.7^{a}	4.2
Drying†	4.5^{b}	4.3^{b}	4.6^{b}	4.2^{b}	4.6^{b}	2.2^{a}	4.1
Shape after laundering†	4.0^{b}	4.1^{b}	4.2^{b}	$3.6^{a,b}$	4.4^{b}	2.1^{a}	3.8
Repairs	*(insufficient η)*						
Brushing	*(insufficient η)*						
Ironing	*(insufficient η)*						
THERMAL TOP							
Shrinkage†	4.0^{b}	3.5^{b}	4.1^{b}	3.4^{b}	4.5^{b}	1.6^{a}	3.6
Washing†	$4.0^{a,b}$	4.1^{b}	4.5^{b}	4.2^{b}	4.5^{b}	2.9^{a}	4.1
Drying†	4.4^{b}	4.1^{b}	4.7^{b}	4.2^{b}	4.5^{b}	2.2^{a}	4.1
Shape after laundering†	4.0^{b}	3.7^{b}	4.2^{b}	3.7^{b}	4.6^{b}	2.1^{a}	3.8
Repairs	*(insufficient η)*						
Brushing	*(insufficient η)*						
Ironing	*(insufficient η)*						

All of the LWTU test conditions were rated very highly for all care parameters. The in-service underwear was rated unacceptable for all parameters, and was rated below largely unacceptable for shrinkage.

3.8.13 Stowage Ratings for Thermal Undergarment Conditions

The exit questionnaires asked participants to rate the acceptability of the stowage characteristics of the thermal undergarments. Participants were asked to rate the acceptability of the undergarment top and bottom in terms of its: stowage in ruck sack, stowage in webbing, stowage in vehicles; as well as the acceptability of the bulk and weight of the thermal undergarment. The mean values for these stowage parameters across the conditions are

† significant effect of condition (α=0.05).

presented in Table 3-25. The ratings were analysed using the same statistical tests described in Section 3-1.

Table 3-25. Mean Stowage Ratings for Thermal Undergarment Conditions.
(unedited data)

☹		😐		☺
1	2	3	4	5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM							
In ruck sack†	4.8[b]	4.9[b]	4.6[b]	4.8[b]	4.7[b]	3.1[a]	4.5
In webbing	*(insufficient η)*						
In vehicles	*(insufficient η)*						
Bulk†	4.7[b]	4.8[b]	4.6[b]	4.4[b]	4.5[b]	2.4[a]	4.3
Weight†	4.8[b]	4.7[b]	4.7[b]	4.8[b]	4.4[a,b]	3.3[a]	4.5
THERMAL TOP							
In ruck sack†	4.7[b]	4.8[b]	4.7[b]	4.8[b]	4.8[b]	3.2[a]	4.5
In webbing	*(insufficient η)*						
In vehicles	*(insufficient η)*						
Bulk†	4.7[b]	4.7[b]	4.5[b]	4.6[b]	4.8[b]	2.9[a]	4.4
Weight†	4.8[b]	4.6[b]	4.5[b]	4.9[b]	4.8[b]	3.1[a]	4.5

Overall mean stowage ratings for the thermal undergarments were very favourable, ranging from 4.3 to 4.5. *In general*, for both the top and the bottoms, the mean acceptability ratings for the stowage in ruck sack, bulk and weight parameters for the prototype conditions were very close to "wholly acceptable", and they were significantly better than those for condition F. Too few participants attempted and/or commented on the stowage in webbing and stowage in vehicles parameters to present mean ratings for the conditions.

3.8.14 Body Function Ratings for Thermal Undergarment Conditions

Participants were asked to provide separate ratings for the ease in eliminating body wastes related to the thermal undergarment top and bottom. Mean body function ratings per condition were calculated for both aspects of this category -- urinating and defecating. These means are

† significant effect of condition (α=0.05).

presented in Table 3-26. The ratings were analysed using the same statistical tests described in Section 3-1.

Ease in eliminating body wastes was quite acceptable for all thermal undergarment conditions. There were no significant differences in the ratings for either of these activities across the conditions.

Table 3-26. Mean Body Function Ratings for Thermal Undergarment Conditions.
(unedited data)

☹ 1		☹ 2		😐 3		4		☺ 5
wholly unacceptable		largely unacceptable		borderline		largely acceptable		wholly acceptable

	Thermal Undergarment Condition						
	A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM							
Urinate (NS)	3.7	4.1	3.9	4.2	4.5	3.8	4.0
Defecate (NS)	4.1	4.2	4.1	4.4	4.2	3.8	4.1
THERMAL TOP							
Urinate (NS)	4.5	4.7	4.4	4.3	4.6	3.9	4.4
Defecate (NS)	4.6	4.8	4.4	4.3	4.6	3.9	4.5

3.8.15 "Other" Ratings for Thermal Undergarment Conditions

Participants were asked to rate the acceptability of several aspects of the thermal undergarments, such as colour, noise, smell when new, smell in use, and layering. Mean ratings for the thermal undergarment conditions across these parameters are presented in Table 3-27. The ratings were analysed using the same statistical tests described in Section 3-1.

There were no significant differences across the conditions in the colour, noise, and smell acceptability ratings. All LWTU test conditions were rated acceptable or better for all parameters, although colour was borderline for Type C and D.

Table 3-27. Mean "Other" Ratings for Thermal Undergarment Conditions.
(unedited data)

☹ 1		☺ 3		☺ 5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

Rating Parameter		Thermal Undergarment Condition						
		A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM								
Colour	(NS)	4.1	3.3	3.0	3.1	4.0	4.1	3.6
Noise	(NS)	4.6	4.7	4.5	4.8	4.7	4.4	4.6
Smell when new	(NS)	4.3	4.2	4.0	4.5	3.9	3.9	4.1
Smell when in use	(NS)	3.5	3.8	4.0	3.8	4.1	2.9	3.7
Allows layering†		4.5^{b}	4.6^{b}	4.6^{b}	$4.3^{a,b}$	4.6^{b}	3.4^{a}	4.3
THERMAL TOP								
Colour	(NS)	4.1	3.4	3.0	3.2	3.8	3.9	3.6
Noise	(NS)	4.5	4.6	4.6	4.7	4.7	4.2	4.6
Smell when new	(NS)	4.3	4.1	4.0	4.6	4.2	3.6	4.2
Smell when in use	(NS)	3.7	3.8	4.0	4.2	4.0	3.1	3.8
Allows layering†		4.6^{b}	4.4^{b}	4.6^{b}	$4.4^{a,b}$	4.8^{b}	3.1^{a}	4.3

3.8.16 Fit Ratings for Thermal Undergarment Conditions

Participants were asked to rate the acceptability of the fit of the thermal undergarments in several areas. Mean fit ratings for the thermal undergarment conditions are in Table 3-28. The ratings were analysed using the same statistical tests described in Section 3-1.

There were no significant differences across the conditions in the fit rating responses for any of the fit areas. In general, the mean ratings were very close to the "OK" fit qualifier for the majority of the fit areas. The mean fit responses for the rise (i.e., crotch length), tended to be rated fairly close to the "too long" qualifier, with mean ratings of 3.4 for conditions A, B, E and F. The mean fit responses for the trunk length (i.e., shirt length) tended to be rated somewhat close to the "too short" qualifier, with mean ratings of 2.6 for conditions E and F and 2.7 for condition D. Shrinkage may have contributed to problems with shirt length, although reduced effectiveness of the waistband in conditions E and F also may have made it difficult to keep the shirt tucked into the drawers. This situation may have caused participants to rate the shirt as too short.

† significant effect of condition (α=0.05).

Table 3-28. Mean Fit Ratings for Thermal Undergarment Conditions.
(edited data)

1	2	3	4	5
unacceptably too small/short	too small/short	OK	too big/long	unacceptably too big/long

		Thermal Undergarment Condition						
		A (η=24)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=113)
THERMAL BOTTOM								
Waist Girth	(NS)	3.1	3.2	2.9	3.0	3.5	3.1	3.1
Hips/Seat Girth	(NS)	3.2	3.2	3.0	3.0	3.1	3.2	3.1
Rise/Crotch Length	(NS)	3.4	3.4	3.1	2.9	3.4	3.4	3.3
Thigh Girth	(NS)	2.9	3.0	2.9	2.9	2.9	3.0	2.9
Knee Girth	(NS)	3.0	3.1	3.0	3.1	2.9	2.9	3.0
Calf Girth	(NS)	3.0	2.9	3.2	2.9	2.9	2.9	3.0
Ankle Girth	(NS)	3.0	3.1	3.2	2.9	3.0	2.5	3.0
Inseam Length	(NS)	3.0	3.0	3.0	3.1	3.3	2.9	3.0
THERMAL TOP								
Neck Girth	(NS)	3.0	3.4	2.8	2.8	2.8	3.3	3.0
Shoulder Breadth	(NS)	2.8	3.2	3.0	2.8	2.9	3.0	2.9
Girth at Underarm	(NS)	2.8	3.0	3.0	2.8	2.8	2.8	2.9
Elbow Girth	(NS)	3.0	2.8	3.0	3.1	2.9	2.8	2.9
Wrist Girth	(NS)	2.9	3.3	2.8	2.9	2.9	2.5	2.9
Chest Girth	(NS)	2.8	3.0	3.0	3.0	2.8	3.0	2.9
Waist Girth	(NS)	2.9	3.1	3.0	2.9	2.6	3.1	2.9
Hips/Seat Girth	(NS)	3.0	3.1	3.0	3.0	2.7	3.3	3.0
Arm Length	(NS)	2.9	3.2	3.0	2.6	3.0	2.5	2.9
Trunk Length	(NS)	3.0	2.8	3.0	2.7	2.6	2.6	2.8

3.8.17 Overall Ratings for Thermal Undergarment Conditions

Participants were asked for separate ratings of the overall acceptability of the thermal undergarment top and the thermal undergarment bottoms in terms of appearance, function, durability and comfort. Mean overall ratings for the thermal undergarment conditions are presented in Table 3-29. The ratings were analysed using the same statistical tests described in Section 3-1.

Table 3-29. Mean Overall Ratings for Thermal Undergarment Conditions.
(edited data)

☹		😐		☺
1	2	3	4	5
wholly unacceptable	largely unacceptable	borderline	largely acceptable	wholly acceptable

	Thermal Undergarment Condition						
	A (η=23)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)	All (η=112)
THERMAL BOTTOM							
Overall Appearance†	$4.1^{a,b}$	$3.7^{a,b}$	3.7^{a}	$4.1^{a,b}$	4.7^{b}	3.6^{a}	4.0
Overall Function†	$3.5^{a,b}$	3.8^{b}	3.9^{b}	4.2^{b}	4.3^{b}	2.3^{a}	3.7
Overall Durability†	$3.8^{a,b}$	4.2^{b}	4.1^{b}	$3.9^{a,b}$	4.6^{b}	2.9^{a}	3.9
Overall Comfort†	4.0^{b}	3.9^{b}	4.3^{b}	4.0^{b}	4.2^{b}	2.5^{a}	3.9
THERMAL TOP							
Overall Appearance†	$4.3^{a,b}$	$3.9^{a,b}$	3.5^{a}	$4.0^{a,b}$	4.7^{b}	3.8^{a}	4.0
Overall Function†	$3.6^{a,b}$	$3.8^{a,b}$	$3.7^{a,b}$	4.1^{b}	4.5^{b}	2.6^{a}	3.7
Overall Durability†	$4.0^{a,b}$	4.2^{b}	4.3^{b}	$4.1^{a,b}$	4.5^{b}	3.1^{a}	4.0
Overall Comfort†	4.1^{b}	$3.9^{a,b}$	4.3^{b}	$3.8^{a,b}$	4.4^{b}	2.6^{a}	3.9

A significant effect of condition was evident for all overall parameters, for both the thermal undergarment top and bottoms. In terms of mean ratings for the entire group, the overall function ratings (3.7) demonstrated slightly less acceptability than the other overall ratings (3.9 to 4.0).

3.8.18 Acceptable Replacement Responses for Thermal Undergarment Conditions

Participants who wore one of the thermal undergarment prototype conditions (i.e., conditions A through E) were asked to indicated whether or not they considered the thermal undergarment, in its present form, an acceptable replacement for the in-service thermal undergarment. A separate response was requested for the top and the bottoms. The percentages of "yes" and "no" responses to this question for the top and bottoms for each condition are presented in Table 3-30.

† significant effect of condition (α=0.05).

Table 3-30. Percent of "Yes" and "No" Response to Acceptable Replacement Question for Thermal Undergarment Conditions.
(edited data)

Response Option	Thermal Undergarment Condition (Dark Shading = Least Favoured; Light Shading = Most Favoured)					
	A (η=23)	B (η=17)	C (η=21)	D (η=17)	E (η=18)	F (η=16)
THERMAL BOTTOM						
Yes	16 (70%)	14 (82%)	14 (67%)	12 (76%)	16 (89%)	n/a
No	7 (30%)	3 (18%)	7 (33%)	5 (24%)	2 (11%)	n/a
THERMAL TOP						
Yes	13 (56%)	11 (65%)	13 (62%)	13 (76%)	16 (89%)	n/a
No	10 (43%)	6 (35%)	8 (38%)	4 (24%)	2 (11%)	n/a

For both the top and the bottoms, the highest percentages of "yes" responses (89%) were received for condition E. For the bottoms, the lowest percentages of "yes" responses (67%) were received for condition C. For the top, the lowest percentages of "yes" responses (56%) were received for condition A.

3.9 Focus Group Results

Condition specific, focus group sessions were conducted with all available trial participants in order to gain first hand information on the performance of the thermal undergarments during the trial period. Summaries of the comments gathered during the focus group sessions are presented in Appendix B in Table B-2 through Table B-7. These comment summaries are structured according to four main topics: general comfort, design issues, material characteristics and general characteristics. The comment summaries in Appendix B also contain the frequencies for each of the comments. These four topics are defined in the following paragraphs.

The *general comfort* of the thermal undergarment was the first topic of group discussion. Comments on the comfort of the undergarment regarding its ability to keep the skin dry and warm in varying temperatures and during a variety of work conditions were gathered. Comments were also gathered on the need and effectiveness of ventilating activities used to keep the thermal undergarment dry or to dry it out while it was still being worn.

The *design issues* of the thermal undergarment that were discussed included general fit and garment shape retention as well as the design of specific garment features such as the neck, cuffs at the ankles and wrists, waist band and access fly. The effect of the design of these features on function, general comfort, thermal comfort, durability, etc. was discussed. Participants were encouraged to identify any adjustments or special considerations they made in order to improve the fit and/or effectiveness of the undergarment. The design issues section also addressed any issues related to donning and/or doffing the undergarment.

The *material characteristics* of the thermal undergarment that were discussed included the general feel of the material in periods of short- or long-term wear; and skin irritations, rashes, or itching caused by the material of the undergarment. The durability of the undergarment was discussed to identify any weaknesses at seams or in specific areas of the garment. The ease of washing, drying and overall care of the garment was also discussed. Participants were asked to comment on any issues related to shrinkage, loss of shape, loss of elasticity and/or static electricity build-up that they experienced with the thermal undergarment condition.

The *general characteristics* of the thermal undergarment that were discussed included any issues not covered in the previous three categories such as: compatibility of the undergarment with the rest of the kit; bulk, weight, stowage and transport issues; affect of the undergarment on mobility; odour of the undergarment when new and while in use; et cetera.

For cross-reference purposes, Table B-1 in Appendix B relates the topics in the focus group comment summaries to the statement of requirement (SOR) reference numbers from the *Requirement Verification Matrix (RVM) for Thermal Underwear* provided by DCIEM (see Appendix C).

A synopsis of the most significant focus group results for each thermal undergarment condition is presented in Appendix B. Comments on certain performance aspects were quite consistent across all prototype conditions (i.e., conditions A through E). These global comments are outlined below and are repeated within each of the condition summaries.

3.9.1 Global Focus Group Comments on LWTU Prototypes

There were a number of comments regarding performance of the thermal undergarments that were consistent across all *prototype* conditions (conditions A through E). Refer to Appendix B for actual frequencies in responses. These global comments are described below:

- Participants were extremely impressed with the stowage performance of all prototype conditions. The prototypes were all considered extremely lightweight and compact -- very easy to stow and carry.

- Participants were impressed with the ease of laundering the prototype thermal undergarments. The quick drying times demonstrated by the prototypes were considered a vast improvement over the drying times required for the in-service thermal undergarment.

- There were rarely concerns regarding either the new or the in-use smell of the prototype undergarments (condition A was one exception).

- All prototype undergarments were received favourably in terms of the feel of the material on the skin. No skin allergies or rashes were evident. Only slight skin irritation was noticed by a very small number of participants across all prototype conditions, and this irritation was never a persistent problem.

- Participants felt that the thermal undergarments should be army-issue colour, either olive drab or black.

- All prototype conditions were easy to don and doff, although a few participants suggested incorporating slide fasteners at the cuffs (for donning/doffing as well as ventilation purposes).

- Participants indicated that the prototype thermal undergarments did not impose additional problems in terms of eliminating body wastes. In cold conditions the fly was rarely used, participants found it much faster to simply pull the waist down on all the layers of clothing in order to urinate. This supports the suitability for a unisex design.

3.9.2 Focus Group Summary for Condition A

The general consensus from the group was that the thermal undergarment condition A did not demonstrate effective wicking capabilities. The undergarment lost its thermal capabilities in cold to very cold temperatures due to significant moisture accumulation. However, the undergarment would dry quickly if ventilation was possible. All participants agreed that ventilation was an effective method of drying the undergarment when in use.

Several comments were received regarding the design of the neck, which was considered much too open. The participants suggested that a design similar to that of the "Norwegian Sleeper" would be a great improvement. The "Norwegian Sleeper" has a high neck with a center front slide fastener that greatly facilitates ventilation (the turtleneck can be folded in half or fully extended over chin according to thermal protection requirements). There was sufficient overlap between the top and the bottom.

The fit of condition A was generally considered good, except for a baggy crotch, which reduced mobility in some activities. The bagginess in the crotch area seemed to be caused by the excessive rise length and/or ineffective waistband elasticity.

Durability concerns were received relatively frequently in regards to rips in the cuffs and the underarm seams. In addition, participants noticed significant static build-up in the undergarment after laundering. Also, about one-third of participants found that the undergarment retained body odour when worn for an extended duration in the field.

3.9.3 Focus Group Summary for Condition B

The participants were clearly impressed with the wicking capabilities of thermal undergarment condition B. Except for heavy work rate scenarios, where the undergarment would become damp, it did not accumulate moisture. The undergarment dried out quickly; opening outer clothing to allow ventilation was not necessary to dry the undergarment. The thermal protection provided by condition B was good, except in extreme cold. Participants reported that the undergarment was too hot for heavy work in cold or cool conditions.

Design modifications for condition B were suggested, such as changing the cuff to a regular ribbed style, rather than a hemmed edge, and incorporating a higher neck -- possibly a turtleneck with a slide fastener similar to the "Norwegian Sleeper" neck design.

Although no signs of wear were reported, all participants expressed concern regarding the durability of the thermal undergarment fabric. The participants felt that the material was too thin, and that it should be reinforced in high wear areas, such as the buttocks, knees, shoulders and elbows. No compatibility problems of condition B with the rest of the clothing items were reported. Shrinkage and static electricity build-up, after machine drying, were evident with condition B.

3.9.4 Focus Group Summary for Condition C

In general, the thermal undergarment condition C was rated highly by the participants. Most participants felt that the wicking capabilities of the undergarment were effective -- the garment did not retain much moisture when they were sweating. A few participants found that the undergarment did accumulate perspiration, and they also found that it required some time to dry out on the body when ventilation opportunities were available. Most participants felt that condition C provided good thermal protection in cold and extreme cold conditions, but that the thermal protection was greatly reduced by wind.

Participants consistently commented on the lack of sufficient overlap between the top and the bottom of the undergarment. There were some complaints regarding sagging in the crotch area. The fit of the neck was considered good; however all participants indicated a preference for a turtleneck with a slide fastener -- to increase thermal protection from the wind and to facilitate ventilation.

Durability of condition C was generally considered good, although a few participants noted waistband breakdown (i.e. pulls) and general fabric wear (i.e., pulls and piling), which did not create any problems during the trial but were considered potential durability problems. A number of participants noticed slight girth shrinkage after laundering the undergarment, but the original fit was restored when it was worn. Participants also commented on the build-up of static electricity after laundering. Condition C demonstrated good compatibility with other clothing items.

3.9.5 Focus Group Summary for Condition D

The thermal undergarment condition D was also well liked by the focus group participants. It provided good wicking performance. During heavy work periods the undergarment would get damp, but with ventilation it would dry out very quickly while on the body. Condition D provided good thermal protection except in extreme cold with low activity levels. It was found too warm by approximately half of the participants for the performance of heavy work in mild cold conditions.

Condition D was considered good fitting. The following design comments were received for the undergarment: the waistband was considered too narrow by a number of participants; the fly opening was considered too small; overlap of the fly panels was large and this aspect of design was well liked by the participants as it provided additional thermal protection.

All participants noticed shrinkage in the undergarment after laundering, as well as significant static electricity build-up. There were no compatibility problems and no durability concerns with condition D.

3.9.6 Focus Group Summary for Condition E

A prime consideration when examining the comments for thermal undergarment condition E is the lack of group consensus on the wicking capabilities of the undergarment. Participants in the first week focus group session indicated that the thermal undergarment was not effective in wicking perspiration away from the skin during heavy work and that a significant amount of moisture was retained in the undergarment. Conversely, participants in the second week indicated that the thermal undergarment effectively wicked moisture away from the skin and stayed dry even when heavy work was performed. All participants felt that condition E provided good skin dryness for low to moderate workloads, and good thermal protection in a variety of conditions.

Fit was a major problem with condition E. Participants indicated that excessive material in the seat and rise, and poor waist elasticity, resulted in a very baggy crotch fit. This bagginess caused chaffing on the inner thighs and reduced mobility by affecting the fit of the outer clothing. In addition, most participants indicated that the top and bottom overlap was insufficient.

Participants were very positive about the neck design of the condition E (i.e., mock turtleneck with slide fastener). They suggested increasing the height of the neck (i.e., provide a true turtleneck) for additional thermal protection. The slide fastener in the neck was very well received in that it facilitated ventilation and the relatively higher neck increased warmth. There were no reports of skin irritation caused by the slide fastener and no reports of operational difficulties with the fastener in the cold.

A few durability concerns were noted for condition E. The waistband elasticity was weak and did not hold the bottoms in place properly. While signs of wear were not noticed on the undergarments, participants felt that the thin fabric would wear out easily. There were no shrinkage or static electricity problems indicated for condition E.

3.9.7 Focus Group Summary for Condition F

In general, the focus group participants regarded undergarment F, the in-service thermal undergarment, as largely unacceptable. The most significant complaints concerned the undergarment retaining significant quantities of moisture (perspiration) -- the soldiers felt cold when they stopped their activity, due to the wet undergarment. Condition F would not dry out on the body when activity levels decreased and ventilation was possible; it would have to be removed for drying purposes. The thermal protection, provided by condition F, was considered very poor, retaining too much moisture. The wet garment against the skin in cold conditions, severely reduced thermal comfort. Given these problems with moisture retention, condition F was not felt suitable for any work other than sentry-type duties.

Many complaints were received regarding the fit of condition F that became worse with wear, due to sagging and bagging. The sagging was especially noticeable in the seat and crotch of the

bottoms. This problem was exaggerated by the poor waistband function -- a few participants noted that they had difficulty keeping the bottoms up. The loose and baggy undergarment fit affected the fit of other clothing, creating folds, which caused pressure points, and resulting in decreased mobility. There was insufficient overlap between the top and the bottom.

Further, the undergarment lacked durability (seams loosened/ripped, fabric wore thin at knees and elbows); it was heavy and bulky and difficult to stow; and it lost elasticity and shape easily. Participants noted severe shrinkage in the garment after the first wash, but it returned to its original shape with wear. The garment took an extremely long time to machine dry (twice as long as any other clothing item), but there was no significant build-up of static electricity due to laundering. Participants indicated that the undergarment retained a body odour smell after long-term wear that could not be removed with washing.

Most participants from focus group session in the second week indicated that they replaced the undergarment with a civilian brand after the first 12 to 20 hours of use because of the problems they experienced with it. The participants suggested that any replacement item for the in-service thermal undergarment would be welcome.

4. SUMMARY & CONCLUSIONS

This chapter presents a summary of the findings of the human factors assessment of the thermal undergarments systems, a list of conclusions based on these results, and recommendations in the form of performance-based specifications for a LWTU system for the CF.

4.1 Findings of the Assessment

The findings of the assessment are summarized in Sections 4.1.1 through 4.1.15 according to features and parameters. The in-service thermal underwear was rated "borderline" to "largely unacceptable" for all of these features and parameters, except for the elimination of body wastes. In many cases the in-service rating was significantly poorer than the LWTU test conditions.

4.1.1 Neck Design

Many participants commented on the design of the neck during the focus groups. There was a strong interest in the turtleneck with a slide (e.g. zipper) fastener, and a definite dislike of neck designs that were open and had a large diameter. The participants said that they wanted a neck design that would provide protection from cold. The statistical results from the exit questionnaire support this desire. Types A and B (medium and large openings) were near borderline for neck function, whereas type E (with the slide fastener) was rated as largely acceptable.

4.1.2 Crotch Length

The crotch length is important functionally, by allowing freedom of movement when crouching, climbing and running. Focus group participants identified some problems with bagging and bunching in the crotch of some LWTU test conditions. A majority of participants given Type E to wear, criticized the garment for its bagginess in the crotch area, suggesting that a more robust elastic at the waist may have alleviated this problem. Indeed Type E was rated the lowest of all LWTU test conditions for crotch function (although not significantly). Also, three participants in the focus group for type A pointed out that the crotch was baggy, and caused problems for some activities (e.g. running and squatting). Some participants wearing Type C also complained of a sagging crotch.

4.1.3 Waistband

There were many comments regarding the durability and function of the waist designs of a number of LTWU test conditions. It should be noted, however, that all of the LTWU test conditions were rated near to, or beyond "largely acceptable", for function, durability and comfort, and "OK" for fit. Participants wearing Types A, C, and D found the elastic in the waistband either too weak or perceived potential breakdown in the elastic. Many felt that the bagginess in the crotch area was probably due to weak elastic in the waistband. There was general agreement that the waistband for Type D should be wider (broader). Most of the participants in the focus group for Type E felt that the elastic in the waistband had deteriorated and weakened with prolonged wear and laundering.

4.1.4 Shirt (Top) Length

Many participants (27) in the focus groups for Types C and E agreed that the shirt (top) length was too short to allow the top to be tucked into the bottoms. Part of the reason for this inadequate over lap between the top and bottoms may be a result of a weak elastic at the waistband, causing the drawers to slide down and pull away from the shirt.

4.1.5 Cuffs

Participants wearing Type A found that the cuffs were prone to tears and fraying after several washing/drying cycles. Those wearing Type B found that the tucked cuffs of their garment were difficult to slide under the over-garment. They suggested that an elastic ribbed type of cuff would resolve this problem.

4.1.6 Material

The material for all of the LWTU test conditions was rated as largely acceptable. However, participants in the focus groups for both Types B and E, stated that the material seemed too thin to be durable. It should be noted, though, that very few instances of wear were reported. This may be a perception only, and not actual fact. Type A suffered the greatest number of complaints including seams coming apart, frayed and torn cuffs, thinning at the knees, and dye bleeding from the fabric when wet. Types A, B, C and D all were prone to high levels of static electricity buildup during the drying portion of the laundering cycle. The material in Type A retained body odour after prolonged wearing, for about one third of the participants.

4.1.7 Adjustability

All the LWTU test conditions were rated "largely acceptable" for all adjustment parameters.

4.1.8 Moisture Control

The materials of each of the LWTU test conditions had to not only be durable, warm and comfortable, but also had to control how moisture was carried away from the surface of the skin (wicking). If the material was effective at wicking, comfort and warmth were improved. According to the focus group sessions, Type A did not wick the moisture away from skin very well. However, the participants in the Type A focus groups did agree that the garment dried very quickly if ventilated. These focus group results are reflected, somewhat, in the exit questionnaire responses, although the rating for Type A is still in the acceptable range. In fact, it has been rated as almost "largely acceptable", indicating that the problem is not severe. The in-service has a mean rating of between "wholly unacceptable" and "largely unacceptable".

4.1.9 Thermal Control

Generally all of the LWTU test conditions were rated acceptable for keeping the body warm. Notably, two test conditions were rated "largely acceptable" (types D and E). However, Type A was rated unacceptable for suitability to extremely cold (less than –30° C) conditions (the in-service was rated even lower, as "largely unacceptable"). Types D and E were rated largely acceptable" for suitability to extremely cold conditions. All of the LWTU test conditions were acceptable in cool (0 ° C to 10 ° C), and all other conditions between these two extremes.

4.1.10 Stowage

All of the LWTU test conditions were easy to stow, and light to carry. Most (all except E) were easy to compress into a small space. Type E was somewhat bulkier, but was lighter and more compressible than the in-service underwear. All of the LWTU test conditions were rated wholly acceptable for all stowage parameters.

4.1.11 Overall Comfort

The rating for the miscellaneous comfort parameters was favourable for all of the LWTU test conditions, although some skin irritation is noted in Type D. This is consistent with that reported during the focus groups, where 2 participants indicated that minor itching occurred during prolonged wear.

4.1.12 Care of the Garment

Type D suffered significant shrinkage, getting a borderline rating. Thirteen participants wearing Type D found noticeable shrinkage, three of them stating that this shrinkage was excessive. All of the other LWTU test conditions were acceptable or largely acceptable for all care parameters.

4.1.13 Elimination of Body Waste

All test conditions, including the in-service underwear, were rated "largely acceptable" for the ease in eliminating body wastes. Most of the participants stated that they rarely used the fly opening, and found that lowering the underwear along with the outer clothing, was the best method for urination.

4.1.14 Colour, Noise, Smell, and Layering

The colour for Types B, C and D were rated as "borderline", while all of the other test conditions were rated "largely acceptable". Favoured colours included olive drab and black. The other parameters (noise, smell and layering) were all rated near or above "largely acceptable" for all conditions.

4.1.15 Overall Fit

All test conditions, including the in-service underwear, were rated "OK" for all fit parameters.

4.2 Conclusions

The main conclusion of the evaluation is that any of the prototype conditions would be a suitable replacement for the in-service condition, for all aspects - function, durability, comfort, compatibility, stowage et cetera. However, two prototypes stand out from the rest.

- Condition E appears to be rated the highest in most categories, having only a few flaws, which should be considered in specifying requirements to the manufacturer. These improvements include crotch and seat design, waistband design and weight (although this parameter may be of less concern).
- The other prototype, which offered promise, was condition D. It too has some areas where improvement is required such as heat build-up during high workload and a longer drying time than the other prototypes.

Other conclusions from the evaluation include:

- the ability of the material to pull moisture from the skin is very important -- lack of this characteristic results in excessive loss of heat when sedentary
- the time in which the garment requires to dry must be short enough (15 to 30 minutes) to allow the wearer to vent the clothing for a short enough time, to dry, while not risking chilling
- the ability of the material to dry completely or partially even when not vented should be considered (only one prototype -- B -- appeared to have this characteristic)
- the ability to vent the garment at the neck was a feature mentioned by the majority of participants as useful -- the slide fastener of condition D was considered ideal; but many suggested that the neck be a full turtleneck rather than a mock turtleneck design as in D
- condition E did require attention to improving the crotch and seat area, in order to reduce the bagging, sagging and bunching that occurs, and an improved waistband that is broader and less prone to stretching and loss of shape
- condition D was also rated highly but requires attention to improving the ability of the material to pull moisture from the surface of the skin (took longer to dry and left some participants wet after high workload activities)

4.3 Recommendations

Table D-1 in Appendix D contains the recommended specifications for the LWTU. References to specific prototype conditions, as evaluated during the study, are made where appropriate.

5. REFERENCES

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APPENDIX A

TRIAL DATA FORMS & QUESTIONNAIRES

APPENDIX A

TRIAL DATA FORMS & QUESTIONNAIRES

This appendix contains the following data forms and questionnaires for the thermal undergarment trial:

1. Thermal Underwear Trial -- Subject Information Sheet (personal information, anthropometric information, and condition number and sizes.
2. Thermal Underwear Trial -- Initial Fitting Questionnaire
3. Thermal Underwear Trial -- Initial Acceptance Questionnaire
4. Exit Questionnaire

SUBJECT INFORMATION SHEET

THERMAL UNDERWEAR TRIAL - SUBJECT INFORMATION SHEET

Personal Information (to be completed by trial participants):

Service Number: __ __ __ __ __ __ __ __ __ **Date:** _____

Unit: _____ **Rank:** _____ **Surname:** _____

Sex: _____ **Age** _____ **yrs**

Demographic/Anthro Information (to be completed by trial staff):

Height (#99) _____ **mm** **Weight (#124)** _____ **kg**

Circumferences/Breadths:

Neck Circ (#80) _____ **mm** **Chest Circ (#33)** _____ **mm**

Waist - preferred (#113) _____ **mm** **Buttock Circ (#23)** _____ **mm**

Scye Circ (#88) _____ **mm**

Heights/Lengths:

Waist Ht - omph (#119) _____ **mm** **Crotch Ht (#38)** _____**mm**

Sleeve Inseam (C31) _____ **mm**

Sleeve Length Spine-Wrist (#96) _____ **mm**

Underwear Type Assigned (Circle One): **A B C D E F**

Underwear Size Selected - Top: _____ **Bottom:** _____

Subject/Observer (O) Comments on Size Selection:

INITIAL FITTING QUESTIONNAIRE

THERMAL UNDERWEAR TRIAL - INITIAL FITTING QUESTIONAIRE

Service Number ☐☐☐☐☐☐☐☐☐

Surname ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Using the following scale, please provide detailed ratings of the fit of the thermal underwear you have been assigned:

1	2	3	4	5
Unacceptably Small/Short	Slightly Small/Short But Acceptable	Good Fit	Slightly Large/Long But Acceptable	Unacceptably Large/Long

Characteristic	Rating 1	2	3	4	5	Comments
Top - Neck Opening	☐	☐	☐	☐	☐	
Top - Sleeve Length	☐	☐	☐	☐	☐	
Top - Sleeve Girth at Biceps	☐	☐	☐	☐	☐	
Top- Cuff Opening Size	☐	☐	☐	☐	☐	
Top - Armpit/Shoulder Size	☐	☐	☐	☐	☐	
Top - Shirt Length	☐	☐	☐	☐	☐	
Top - Chest Girth	☐	☐	☐	☐	☐	
Top - Waist Girth	☐	☐	☐	☐	☐	
Top - Overall Fit	☐	☐	☐	☐	☐	
Bottom - Waist Opening	☐	☐	☐	☐	☐	
Bottom - Buttock/Hip Girth	☐	☐	☐	☐	☐	
Bottom - Thigh Girth	☐	☐	☐	☐	☐	
Bottom - Cuff Opening Size	☐	☐	☐	☐	☐	
Bottom - Leg length	☐	☐	☐	☐	☐	
Bottom - Crotch Length	☐	☐	☐	☐	☐	
Bottom - Overall Fit	☐	☐	☐	☐	☐	

Additional Comments:

INITIAL ACCEPTANCE RATINGS

THERMAL UNDERWEAR TRIAL - INITIAL ACCEPTANCE RATINGS

Thank you for taking the time to participate in this trial. Your input will be extremely valuable in the selection of new thermal underwear. Please complete all questions as carefully and honestly as you can, don't hesitate to ask the trial staff if you have ANY questions. Thank you!

Service Number ☐☐☐☐☐☐☐☐☐

Surname ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Please rate the underwear, for each of the following characteristics listed by marking an X in the appropriate box of the rating scale described below:

Completely Unacceptable	Largely Unacceptable	Borderline	Largely Acceptable	Completely Acceptable
1	2	3	4	5

Characteristics	Rating 1	2	3	4	5	Comments
Underwear Top -Design	☐	☐	☐	☐	☐	
Underwear Bottom - Design	☐	☐	☐	☐	☐	
Ease of Donning Top (putting on)	☐	☐	☐	☐	☐	
Ease of Donning Bottom	☐	☐	☐	☐	☐	
Ease of Doffing top (taking off)	☐	☐	☐	☐	☐	
Ease of Doffing Bottom	☐	☐	☐	☐	☐	
Physical Comfort of Top	☐	☐	☐	☐	☐	
Physical Comfort of Bottom	☐	☐	☐	☐	☐	
Range of Motion Top	☐	☐	☐	☐	☐	
Range of Motion Bottom	☐	☐	☐	☐	☐	
First Impressions:						
Appearance	☐	☐	☐	☐	☐	
Durability	☐	☐	☐	☐	☐	
Thermal Protection	☐	☐	☐	☐	☐	

Please indicate your specific concerns, problem areas or recommendations in the comments column or on the back of the page. Your individual & honest opinions are critical for the selection of an effective replacement thermal underwear!

Exit Questionnaire

This questionnaire asks for your feedback on the performance of the thermal undergarment (drawers and top) that you wore during the trial period.

How the Questionnaire is Organized:

- The first four pages of the questionnaire ask about the performance of the thermal undergarment drawers.
- The last four pages of the questionnaire ask about the performance of the thermal undergarment top.
- The questions on each page are separated into several sections -- there are six sections for each garment (*Conditions of Wear*, *Specific Features*, *Whole Item*, *Fit*, *Overall Ratings*, and *Comments*).

How to Respond to the Questions:

- For most of the questions, a five-point rating scale is provided for your response.
- You respond by filling in one of the five squares below the rating symbol that most closely matches your experience with the garment.
- The 5-point rating scale looks like this:

Rating Scale Definition

☹ ①	②	😐 ③	④	☺ ⑤
Wholly Unacceptable	Largely Unacceptable	Borderline	Largely Acceptable	Wholly Acceptable
Filling in this box indicates that the garment was **completely unacceptable** in a category.	Filling in this box indicates that the garment was **largely unacceptable** in a category	Filling in this box indicates that the garment was **of borderline acceptability** in a	Filling in this box indicates that the garment was **largely acceptable** in a category.	Filling in this box indicates that the garment was **completely acceptable** in a category.

For example, part of a question from the "Specific Features" section of a questionnaire on webbing is presented below, with sample responses indicated.

Section A: Specific Features

Rate each feature in terms of its function and durability

Feature	Function (works well) ☹ 1 2 3 4 5 ☺	Durability (wears well) ☹ 1 2 3 4 5 ☺
1. Utility Belt	☐ ■ ☐ ☐ ☐	■ ☐ ☐ ☐ ☐
2. Bayonet Holder	☐ ☐ ☐ ☐ ■	☐ ■ ☐ ☐ ☐
3. Canteen Carrier	☐ ☐ ☐ ☐ ■	■ ☐ ☐ ☐ ■
~~4. KFS Carrier~~	~~☐ ☐ ☐ ☐ ☐~~	~~☐ ☐ ☐ ☐ ☐~~

Just a Few Rules:

- ***Fill in only one box per question***. If you want to change your response, just leave the response you already filled, fill the box for the response you want and then **circle it** (see example for durability of Canteen Carrier, in the sample question above).

- ***Answer every question***. If a specific question does not apply to your experience with the garment, draw a line through the words of the question and the response boxes. (For example, item 4 in the sample question above, the KFS Carrier, had never been used and so the response boxes for function and durability were crossed out.)

- Remember, ***this is not a test***. There are no "correct" answers, we want *your* honest opinion.

- When you get to the "Comment Section" ***don't worry about spelling*** ... we want your ideas.

Terminology:

Refer to the definitions below to clarify the meaning of terms used in the questionnaire.

Activities	Does the garment interfere with your performance of the listed activities in any way?
Adjustment	Is the garment easy to put on and take off?
Appearance	Does the garment look good?
Care	Is it easy to keep the garment in good working order and looking good?
Comfort	Does the garment or garment feature feel good on the body when worn?
Compatibility	Does the garment work and fit well when used with the items listed?
Durability	How well does the garment or garment feature wear (i.e., stand up to repeated use)?
Fit	Does the garment fit your body shape and size?
Frequently	Did you wear the garment on a regular basis.
Function	Does the garment or garment feature work well?
High Workload	Is the garment appropriate to wear when you perform strenuous physical labour?
IECS	Integrated Environmental Clothing System.
Layering	How was the fit of the garment affected by clothing layers worn above and below it?
Low Workload	Is the garment appropriate to wear when you perform low intensity (easy) physical labour?
Movement	Is your movement restricted in any way by the item?
Noise	Does the garment create noticeable noise when worn?
Occasionally	Did you wear the item on an irregular or infrequent basis?
Stowage	Is the garment easy to pack and store?
Suitable	Is the garment appropriate for use in the climate conditions identified?

D R W T H E

Underwear type ☐ Service Number ☐☐☐☐☐☐☐☐☐ Unit ☐☐☐☐☐

Rank: Private ☐ Junior NCO ☐ Senior NCO ☐ Officer ☐

Rating Scale Definition

☹		😐		☺
①	②	③	④	⑤
Wholly Unacceptable	Largely Unacceptable	Borderline	Largely Acceptable	Wholly Acceptable

Section A: Conditions of Wear

I have worn this garment in **cool conditions** (i.e., > 0 °C):	I have worn this garment in **cold conditions** (i.e., between -0 °C and -15 °C):	I have worn this garment in **very cold conditions** (i.e., between -15 and -30 °C):	I have worn this garment in **extreme cold conditions** (i.e., less than -30 °C):
☐ Never	☐ Never	☐ Never	☐ Never
☐ Occasionally	☐ Occasionally	☐ Occasionally	☐ Occasionally
☐ Frequently	☐ Frequently	☐ Frequently	☐ Frequently
Max. Time Worn: ☐☐	Max. Time Worn: ☐☐	Max. Time Worn: ☐☐	Max. Time Worn: ☐☐

(give maximum time worn, on any one occasion, to the nearest hour)

Section B: Specific Features

Feature or Area	**Function** (works well) ☹ 😐 ☺ 1 2 3 4 5	**Durability** (wears well) ☹ 😐 ☺ 1 2 3 4 5	**Comfort** (feels good) ☹ 😐 ☺ 1 2 3 4 5
1. Waist elastic	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
2. Access flap	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
3. Hips/seat (girth)	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
4. Crotch	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
5. Thigh	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
6. Knee	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
7. Calf/Shin (girth)	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
8. Cuff at ankle	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
9. All seams	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
10. Fabric	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐

Service Number

Section C: Whole Item

Activities:	☹ 1	2	😐 3	4	☺ 5
Trunk bending	☐	☐	☐	☐	☐
Crouching	☐	☐	☐	☐	☐
Sitting	☐	☐	☐	☐	☐
Crawling	☐	☐	☐	☐	☐
Climbing	☐	☐	☐	☐	☐
Marching	☐	☐	☐	☐	☐
Running	☐	☐	☐	☐	☐
Digging	☐	☐	☐	☐	☐
X-country skiing	☐	☐	☐	☐	☐
Standing	☐	☐	☐	☐	☐
Lying prone (facing down)	☐	☐	☐	☐	☐
Field living	☐	☐	☐	☐	☐
Snowshoeing	☐	☐	☐	☐	☐
Sentry/Piquet	☐	☐	☐	☐	☐
Patrolling	☐	☐	☐	☐	☐
Driving Over-snow vehicles	☐	☐	☐	☐	☐
Erecting/striking tents	☐	☐	☐	☐	☐
Stove watch	☐	☐	☐	☐	☐
Fire weapons	☐	☐	☐	☐	☐
Construct snow	☐	☐	☐	☐	☐
Construct snow	☐	☐	☐	☐	☐
Operating vehicles	☐	☐	☐	☐	☐
Entry into vehicles	☐	☐	☐	☐	☐
Exit from vehicles	☐	☐	☐	☐	☐
Maintenance of vehicles	☐	☐	☐	☐	☐
Other - please specify _____	☐	☐	☐	☐	☐

Suitable for:	☹ 1	2	😐 3	4	☺ 5
Extreme cold (<30C)	☐	☐	☐	☐	☐
Very cold (-15 to -30C)	☐	☐	☐	☐	☐
Cold weather (0 to -15C)	☐	☐	☐	☐	☐
Cool weather (0 to +10C)	☐	☐	☐	☐	☐
Wind	☐	☐	☐	☐	☐
Snow	☐	☐	☐	☐	☐
Rain	☐	☐	☐	☐	☐
Low workload	☐	☐	☐	☐	☐
Medium workload	☐	☐	☐	☐	☐
High workload	☐	☐	☐	☐	☐
Adjustment:	☹ 1	2	😐 3	4	☺ 5
Easy to put on	☐	☐	☐	☐	☐
Easy to take off	☐	☐	☐	☐	☐
Stays in place when worn	☐	☐	☐	☐	☐
Conforms to body shape	☐	☐	☐	☐	☐
Comfort:	☹ 1	2	😐 3	4	☺ 5
Keeps skin dry	☐	☐	☐	☐	☐
Keeps body warm	☐	☐	☐	☐	☐
"Feel" of material	☐	☐	☐	☐	☐
Skin irritation (e.g. chafing)	☐	☐	☐	☐	☐
Skin allergies (e.g. rash)	☐	☐	☐	☐	☐
Pressure points	☐	☐	☐	☐	☐
Overall - Short-term wear	☐	☐	☐	☐	☐
Overall - Long-term wear	☐	☐	☐	☐	☐

Whole Item (Con't)

Service Number ☐☐☐☐☐☐☐☐☐

Durability:	☹ 1	2	😐 3	4	☺ 5
Tears (actual separation)	☐	☐	☐	☐	☐
Wear (thinning of fabric)	☐	☐	☐	☐	☐
Snagging	☐	☐	☐	☐	☐
Stitching	☐	☐	☐	☐	☐
Stains	☐	☐	☐	☐	☐
Sagging/bagging	☐	☐	☐	☐	☐
Elastic at cuff at the ankle	☐	☐	☐	☐	☐
Elastic at waist	☐	☐	☐	☐	☐
Ease in Eliminating Body Wastes:	☹ 1	2	😐 3	4	☺ 5
Urinating	☐	☐	☐	☐	☐
Defecating	☐	☐	☐	☐	☐
Care:	☹ 1	2	😐 3	4	☺ 5
Shrinkage	☐	☐	☐	☐	☐
Washing	☐	☐	☐	☐	☐
Drying	☐	☐	☐	☐	☐
Repairs	☐	☐	☐	☐	☐
Brushing	☐	☐	☐	☐	☐
Ironing	☐	☐	☐	☐	☐
Shape of item after laundering	☐	☐	☐	☐	☐

Compatibility:	☹ 1	2	😐 3	4	☺ 5
Top, thermal	☐	☐	☐	☐	☐
Trousers, combat	☐	☐	☐	☐	☐
Trousers, Arctic	☐	☐	☐	☐	☐
Socks, Gortex	☐	☐	☐	☐	☐
Socks, wool	☐	☐	☐	☐	☐
Boot liner	☐	☐	☐	☐	☐
Boot, combat	☐	☐	☐	☐	☐
Boot, arctic	☐	☐	☐	☐	☐
IECS - uninsulated pant	☐	☐	☐	☐	☐
IECS - insulated pant	☐	☐	☐	☐	☐
Fleece bottoms	☐	☐	☐	☐	☐
Other:	☹ 1	2	😐 3	4	☺ 5
Colour	☐	☐	☐	☐	☐
Noise	☐	☐	☐	☐	☐
Smell when new	☐	☐	☐	☐	☐
Smell when in use	☐	☐	☐	☐	☐
Allows Layering	☐	☐	☐	☐	☐
Stowage:	☹ 1	2	😐 3	4	☺ 5
In ruck sack	☐	☐	☐	☐	☐
In webbing	☐	☐	☐	☐	☐
In vehicles	☐	☐	☐	☐	☐
Bulk	☐	☐	☐	☐	☐
Weight	☐	☐	☐	☐	☐

Section D: Fit

Service Number | | | | | | | | | |

	Unacceptably Too Small/Short 1	2	OK 3	4	Unacceptably Too Big/Long 5
Waist	☐	☐	☐	☐	☐
Hips/seat	☐	☐	☐	☐	☐
Rise	☐	☐	☐	☐	☐
Thigh	☐	☐	☐	☐	☐
Knee	☐	☐	☐	☐	☐
Calf	☐	☐	☐	☐	☐
Ankle	☐	☐	☐	☐	☐
Inseam	☐	☐	☐	☐	☐

Section E: Overall Ratings

	☹ 1	2	😐 3	4	☺ 5
Overall Appearance	☐	☐	☐	☐	☐
Overall Function	☐	☐	☐	☐	☐

	☹ 1	2	😐 3	4	☺ 5
Overall Durability	☐	☐	☐	☐	☐
Overall Comfort	☐	☐	☐	☐	☐

Is this prototype garment, <u>in the present form</u>, an acceptable replacement for the current longjohn bottoms? ☐ Yes ☐ No

If your answer is no, why not?

_____

_____

_____

_____

_____

_____

_____

Section F: Comments

Service Number

THERTOP 1

Underwear Type ☐ Service Number ☐☐☐☐☐☐☐☐☐ Unit ☐☐☐☐☐

Rating Scale Definition

☹ ①		😐 ③		☺ ⑤
Wholly Unacceptable	Largely Unacceptable	Borderline	Largely Acceptable	Wholly Acceptable

Section A: Conditions of Wear

I have worn this garment in **cool conditions** (i.e., 0 to +10 °C):	I have worn this garment in **cold conditions** (i.e., between -0 °C and -15 °C):	I have worn this garment in **very cold conditions** (i.e., between -15 and -30 °C):	I have worn this garment in **extreme cold conditions** (i.e., less than -30 °C):
☐ Never	☐ Never	☐ Never	☐ Never
☐ Occasionally	☐ Occasionally	☐ Occasionally	☐ Occasionally
☐ Frequently	☐ Frequently	☐ Frequently	☐ Frequently
Max. Time Worn: ☐☐	Max. Time Worn: ☐☐	Max. Time Worn: ☐☐	Max. Time Worn: ☐☐

(give maximum time worn, on any one occasion, to the nearest hour)

Section B: Specific Features

Feature or Area	**Function** (works well) ☹ 😐 ☺ 1 2 3 4 5	**Durability** (wears well) ☹ 😐 ☺ 1 2 3 4 5	**Comfort** (feels good) ☹ 😐 ☺ 1 2 3 4 5
1. Neck	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
2. Shoulder	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
3. Underarm	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
4. Elbow	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
5. Cuff at wrist	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
6. Bottom Edge	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
7. All seams	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐
8. Fabric	☐☐☐☐☐	☐☐☐☐☐	☐☐☐☐☐

Section C: Whole Item

Service Number | | | | | | | | | |

Activities:	☹ 1	2	3	4	☺ 5
Trunk bending	☐	☐	☐	☐	☐
Crouching	☐	☐	☐	☐	☐
Sitting	☐	☐	☐	☐	☐
Crawling	☐	☐	☐	☐	☐
Climbing	☐	☐	☐	☐	☐
Marching	☐	☐	☐	☐	☐
Running	☐	☐	☐	☐	☐
Digging	☐	☐	☐	☐	☐
X-country skiing	☐	☐	☐	☐	☐
Standing	☐	☐	☐	☐	☐
Lying prone (facing down)	☐	☐	☐	☐	☐
Field living	☐	☐	☐	☐	☐
Snowshoeing	☐	☐	☐	☐	☐
Sentry/Piquet	☐	☐	☐	☐	☐
Patrolling	☐	☐	☐	☐	☐
Erecting/striking tents	☐	☐	☐	☐	☐
Stove watch	☐	☐	☐	☐	☐
Fire weapons	☐	☐	☐	☐	☐
Construct snow defences	☐	☐	☐	☐	☐
Construct snow shelters	☐	☐	☐	☐	☐
Operating vehicles	☐	☐	☐	☐	☐
Entry into vehicle	☐	☐	☐	☐	☐
Exit from vehicle	☐	☐	☐	☐	☐
Maintenance of vehicle	☐	☐	☐	☐	☐
Durability:	☹ 1	2	3	4	☺ 5
Tears	☐	☐	☐	☐	☐
Wear	☐	☐	☐	☐	☐
Snagging	☐	☐	☐	☐	☐
Stitching	☐	☐	☐	☐	☐
Stains	☐	☐	☐	☐	☐
Material	☐	☐	☐	☐	☐
Elastic at cuff at the wrist	☐	☐	☐	☐	☐
Elastic at bottom edge	☐	☐	☐	☐	☐

Suitable for:	☹ 1	2	3	4	☺ 5
Extreme cold (<30C)	☐	☐	☐	☐	☐
Very cold (-15 to -30C)	☐	☐	☐	☐	☐
Cold weather (0 to -15C)	☐	☐	☐	☐	☐
Cool weather (0 to +10C)	☐	☐	☐	☐	☐
Wind	☐	☐	☐	☐	☐
Snow	☐	☐	☐	☐	☐
Rain	☐	☐	☐	☐	☐
Medium workload	☐	☐	☐	☐	☐
High workload	☐	☐	☐	☐	☐
Adjustment:	☹ 1	2	3	4	☺ 5
Easy to put on	☐	☐	☐	☐	☐
Easy to take off	☐	☐	☐	☐	☐
Stays in place when worn	☐	☐	☐	☐	☐
Conforms to body shape	☐	☐	☐	☐	☐
Comfort:	☹ 1	2	3	4	☺ 5
Keeps skin dry	☐	☐	☐	☐	☐
Keeps skin warm	☐	☐	☐	☐	☐
"Feel" of material	☐	☐	☐	☐	☐
Skin irritation (e.g. chafing)	☐	☐	☐	☐	☐
Skin allergies (e.g. rash)	☐	☐	☐	☐	☐
Pressure points	☐	☐	☐	☐	☐
Short-term wear	☐	☐	☐	☐	☐
Long-term wear	☐	☐	☐	☐	☐
Compatibility:	☹ 1	2	3	4	☺ 5
Drawers, thermal	☐	☐	☐	☐	☐
Shirt, work dress	☐	☐	☐	☐	☐
Jacket, combat	☐	☐	☐	☐	☐
Jacket, Arctic	☐	☐	☐	☐	☐
Gloves, combat	☐	☐	☐	☐	☐
Gloves, Arctic	☐	☐	☐	☐	☐
Hood, Arctic	☐	☐	☐	☐	☐
IECS uninsulated	☐	☐	☐	☐	☐
IECS insulated	☐	☐	☐	☐	☐

Section C: Whole Item (continued)

Service Number | | | | | | | | | |

Ease in Eliminating Body Wastes:	☹ 1	2	😐 3	4	☺ 5
Urinating	☐	☐	☐	☐	☐
Defecating	☐	☐	☐	☐	☐
Care:	☹ 1	2	😐 3	4	☺ 5
Shrinkage	☐	☐	☐	☐	☐
Washing	☐	☐	☐	☐	☐
Drying	☐	☐	☐	☐	☐
Repairs	☐	☐	☐	☐	☐
Brushing	☐	☐	☐	☐	☐
Ironing	☐	☐	☐	☐	☐
Shape of item after laundering	☐	☐	☐	☐	☐

Other:	☹ 1	2	😐 3	4	☺ 5
Colour	☐	☐	☐	☐	☐
Noise	☐	☐	☐	☐	☐
Smell when new	☐	☐	☐	☐	☐
Smell when in use	☐	☐	☐	☐	☐
Allows Layering	☐	☐	☐	☐	☐
Stowage:	☹ 1	2	😐 3	4	☺ 5
In ruck sack	☐	☐	☐	☐	☐
In webbing	☐	☐	☐	☐	☐
In vehicles	☐	☐	☐	☐	☐
Bulk	☐	☐	☐	☐	☐
Weight	☐	☐	☐	☐	☐

Section D: Fit

	Unacceptably Too Small/Short 1	2	OK 3	Unacceptably Too Big/Long 4	5
Neck	☐	☐	☐	☐	☐
Shoulder Breadth	☐	☐	☐	☐	☐
Underarm	☐	☐	☐	☐	☐
Elbow	☐	☐	☐	☐	☐
Wrist	☐	☐	☐	☐	☐
Chest	☐	☐	☐	☐	☐
Waist	☐	☐	☐	☐	☐
Hips/seat	☐	☐	☐	☐	☐
Arm Length	☐	☐	☐	☐	☐
Trunk Length	☐	☐	☐	☐	☐

Section E: Overall Ratings

Service Number | | | | | | | | | |

	☹ 1	2	😐 3	4	☺ 5
Overall Appearance	☐	☐	☐	☐	☐
Overall Function	☐	☐	☐	☐	☐

	☹ 1	2	😐 3	4	☺ 5
Overall Durability	☐	☐	☐	☐	☐
Overall Comfort	☐	☐	☐	☐	☐

Is this prototype garment, in the present form, an acceptable replacement for the current longjohn top? ☐ Yes ☐ No

If your answer is no, why not? _____

_____

_____

Section F: Comments

APPENDIX B

FOCUS GROUP SUMMARY TABLES

The focus group summary comments presented in Table B-2 through Table B-7 are all identified as being either positive, negative or neutral comments about the performance of the thermal undergarment. That is, each comment is led by either a "+" (positive), "-" (negative), or "✱" (neutral) sign. The frequency with which each comment was made for a given thermal undergarment condition is noted in the far right column of the table. When reviewing the focus group summaries these frequency figures are important to note, as certain comments were fairly consistent within a particular group or were unique to only a few individuals in the group.

Table B-2. Focus Group Comment Summary for Thermal Undergarment Condition A.

Condition A (n=25)		
Categories	**Comments**	**Frequency**
1) GENERAL COMFORT		
Skin Dryness		
a) wicking effect	- undergarment was not effective in wicking moisture away from skin.	**14**
	+ wicking was effective during moderate workloads when there was only slight perspiration.	**3**
b) accumulation of perspiration	- undergarment would retain perspiration during periods of heavy sweating, (i.e., heavy workloads), or over long periods of wear while working at moderate rates.	**ALL**
c) workload conditions	- undergarment was suitable only under low to moderate workload conditions where there was no heavy perspiration.	**ALL**
	- if work was begun indoors, perspiration accumulated and undergarment would retain moisture and was damp/wet when work moved outdoors.	**6**
Body Warmth		
a) specific temperatures	+ warmth was good in cold to very cold temperatures, with no wind.	**ALL**
	- at extreme cold conditions, the undergarment was not warm, even with layering system of fleece, shell and parka.	**8**
b) specific workloads	+ the undergarment was warm while working in all temperatures with the exception of extreme cold. When work stopped, the accumulation of moisture made the undergarment cold.	**ALL**
	- while running in very cold conditions, one participant received frostbite in the genital area.	**1**
Drying Ability		
a) on the body	+ the undergarment dried quickly if	**20**

Condition A (n=25)

Categories	Comments	Frequency
	ventilation possible.	
b) ventilation	+ undergarment easy to ventilate.	20
2) DESIGN ISSUES		
General Fit/Function		
	+ general fit of the undergarment was acceptable.	ALL
	- rise was too long, causing bagginess in the crotch area.	11
	- sleeves twisted and did not stay in place.	1
	+ good level of overlap between top and bottom.	24
	- shirt could be longer for better overlap.	1
(a) neck	- neck lost shape after initial wash.	11
	- neck was too open and allowed wind to penetrate at neck and, decreased the warmth provided by the undergarment -- several references were made to the benefits of the neck design on the Norwegian Sleeper (see summary at end of table for details).	11
	+ neck was comfortable and did not lose shape.	4
(b) cuffs at ankle and wrist	- cuffs at ankle and wrist were too tight at issue, but there was some stretch after wash and wear.	11
(c) waist elastic	- broader waist elastic would be more comfortable.	19
	+ waist elastic, in general, was comfortable.	19
	- waist elastic caused pressure points at the hips.	2
(d) access flap (fly)	+ no problems encountered.	ALL
Adjustments		
	- undergarment was not worn because it was too constrictive (in-service undergarment preferred).	1
	- extra thermal under layer was required to	1

Condition A (n=25)

Categories	Comments	Frequency
	improve warmth.	
Donning and Doffing		
	✸ no comments	
3) MATERIAL CHARACTERISTICS		
Feel of the Material		
a) short-term vs. long-term wear	+ feel of material was acceptable.	19
	- cuffs caused a slight heat rash reaction, (may have been a function of the general fit).	1
	- discomfort caused by hair on thighs pulled through the fibers of the undergarment.	1
Durability		
	- seams were not strong, rips and/or separations in the underarm area were experienced.	3
	- tears and separations occurred at most cuffs.	1
	- dye of material showed up on kit, (bled to other clothing after initial wash).	2
	- material thinned considerably at the knees.	3
Washing and Care		
a) washing and drying	- the undergarment lost shape at the neck each time it was washed.	1
	+ the undergarment did not shrink with washing or drying.	17
	- the undergarment had minimal shrinkage after washing and drying.	3
b) static	- the undergarment had a great deal of static electricity after laundering.	17
c) repairs	✸ no comments	
4) GENERAL CHARACTERISTICS		
Compatibility		

Condition A (n=25)

Categories	Comments	Frequency
	- the undergarment was baggy in the crotch area and would sag noticeably during squatting, repelling, or bending -- this limited range of motion.	8
	- shirt did not always stayed tucked into the bottoms.	1
	- skin irritation at inner thigh due to bagginess.	2
	+ no restriction of activities at all.	14
	+ tightness of ankle cuff was effective in keeping socks from drooping.	1
Stowage		
	+ good stowage -- light and compact.	ALL
Odour		
	+ smell acceptable when new.	9
	- held body odour when worn for an extended duration in the field.	8
	+ acceptable smell when in use and no smell detectable when new.	11

Table B-3. Focus Group Comment Summary for Thermal Undergarment Condition B.

Condition B (n=16)		
Categories	**Comments**	**Frequency**
1) GENERAL COMFORT		
Skin Dryness		
a) wicking effect	+ participants were impressed with the ability of the undergarment to move moisture away from the skin.	**ALL**
b) accumulation of perspiration	+ the undergarment did not get damp from perspiration.	**ALL**
c) workload conditions	+ the undergarment may become damp during heavy workload conditions, however, it dried out quickly.	**ALL**
Body Warmth		
a) specific temperatures	+ participants were comfortable in cold to very cold conditions.	**8**
	- thermal capability was not as good in extreme cold conditions, particularly during low workloads.	**8**
b) specific workloads	- participants were too warm when performing heavy workloads in cold conditions.	**8**
Drying Ability		
a) on the body	+ undergarment dried quickly when next to the skin if it became damp.	**ALL**
b) ventilation	+ no ventilation of outerwear was needed to facilitate the drying of the material.	**ALL**
2) DESIGN ISSUES		
General Fit/Function		
a) neck	+/- participants were evenly split on the fit of the neck; (i.e., good fit vs. too wide fit).	
	✸ participants felt that a turtleneck design with a zippered neck would improve warmth and facilitate ventilation.	**ALL**
b) cuffs at ankle and wrist	- cuffs were too loose on issue and stretched	**5**

Condition B (n=16)

Categories	Comments	Frequency
	further and continued to loose shape with use.	
	- preference for a true cuff rather than a turned hemmed edge.	8
	+ participants would prefer a looser cuff.	2
c) waist elastic	+ waist elastic was acceptable.	15
	-waist elastic was too tight.	1
d) access flap (fly)	✸ most of the participants did not use the access flap because of the cold; to urinate they simply pulled the waistbands down on all their clothing layers.	
3) MATERIAL CHARACTERISTICS		
Feel of the Material		
a) short-term vs. long-term wear	- irritation of the skin on legs (no rash) -- not a persistent problem.	1
	- found the material itchy during long-term wear.	1
	- fibers of material pulled on body hair.	1
Durability		
	- perception that the material was too thin and therefore would not be durable (but no evidence of wear).	ALL
	✸ suggested adding material to high wear areas such as the knees.	
Washing and Care		
a) washing and drying	- after drying, shrinkage of the undergarment was a significant problem.	9
b) static	- significant static build-up after drying in the dryer.	8
c) repairs	✸ no comments	
4) GENERAL CHARACTERISTICS		
Compatibility		
	+ the undergarment was compatible with all	ALL

Condition B (n=16)

Categories	Comments	Frequency
	clothing layers. - cuffs of the top extended out to hands and hampered use of the gloves. - in-service undergarments worn in addition to the undergarment in order to improve warmth.	2 2
Stowage	+ excellent stowage.	ALL
Odour	+ no problems with the new smell and no retention of body odour that was out of the ordinary for the long, continuous wear periods.	ALL

Table B-4. Focus Group Comment Summary for Thermal Undergarment Condition C.

Condition C (n=20)		
Categories	**Comments**	**Frequency**
1) GENERAL COMFORT		
Skin Dryness		
a) wicking effect	+ wicking of the undergarment was effective; the undergarment remained dry, while the undershirt was damp.	**16**
	- undergarment did not wick moisture away and held dampness and perspiration.	**4**
b) accumulation of perspiration	+ no accumulation of perspiration.	**15**
	- undergarment retained moisture when perspiring.	**4**
	- noticeable moisture accumulation at the wrist, possibly due to snugness of fit.	**1**
c) workload conditions	✷ no comments	
Body Warmth		
a) specific temperatures	+ undergarment had good thermal capability in cold to extreme cold temperatures; great improvement over in-service thermal capabilities.	**10**
	- undergarment provided no wind protection.	**8**
	- undergarment did not keep body warm in very cold to extreme cold temperatures unless a polar fleece was worn.	**8**
b) specific workloads	- undergarment kept participants warm in cold to very cold conditions provided they were performing moderate to high workload activities.	**17**
Drying Ability		
a) on the body	+ the undergarment wicked and transferred moisture well and stayed dry on the body.	**16**
	- the undergarment did not stay dry and was damp next to the skin.	**4**
b) ventilation	- the undergarment would dry when	**4**

Condition C (n=20)

Categories	Comments	Frequency
	ventilated, but took some time (approximately 10-20 minutes), after cessation of work (drying time varied with level of moisture that had accumulated).	
2) DESIGN ISSUES		
General Fit/Function		
	+ in general undergarment was form-fitting and comfortable.	**ALL**
	- bottoms were baggy in the seat.	**3**
	+ undergarment retained its shape well.	**3**
	- top did not provide enough coverage, pulled out of bottoms when bending.	**12**
a) neck	+ fit at neck was good, but could be improved with a zipper to: increase warmth, protect from the wind and facilitate ventilation.	**ALL**
b) cuffs at the ankle and wrist	+ cuffs provided good fit.	**8**
	- cuffs were too constrictive after extended wear.	**1**
	+ cuffs were not snug and sleeves were too long.	**1**
c) waist elastic	- with use, the waistband began to break down and fray; this wear did not seem to affect elasticity.	**2**
d) access flap (fly)	- access flap was too low and difficult to use. ✸ most participants did not use the access flap, they preferred pulling down their clothing layers at the waist elastic.	**2**
Adjustments		
	- larger size bottom required for girth fit, but the rise was so long it had to be rolled over at the waist to compensate.	**1**
Donning and Doffing		
	+ no problems donning or doffing. ✸ suggestion to include a zipper at the ankle cuff as the ankle cuffs can be too tight.	**ALL**

Condition C (n=20)

Categories	Comments	Frequency
3) MATERIAL CHARACTERISTICS		
Feel of the Material		
a) short-term vs. long-term wear	+ the undergarment material was comfortable both in short-term and long-term wear.	15
	- after long-term wear, (i.e., > 48 hours), a rash developed on inner thigh.	1
	- material caused friction and irritation at the nipples and genitals when running.	1
Durability		
	- some piling of the material after 4 weeks wear; material collected lint and debris which was difficult to remove.	2
	✸ noticed pulls in fabric; no affect on performance of the undergarment.	1
	+ good seam durability.	19
	- waistband broke down with use and washing; no noticeable affect on elasticity.	2
Washing and Care		
a) washing and drying	+ no shrinkage in undergarment length, slight shrinkage in the girth which was restored with normal wear.	17
	- undergarment shrank after washing and drying (seemed to result from putting the undergarment in the dryer).	3
b) static	- significant static after laundering.	ALL
	- noticeable static when donning and when climbing out of sleeping bag.	1
c) repairs	✸ no comments	
4) GENERAL CHARACTERISTICS		
Compatibility		
	- overlap of cuffs and socks was too tight and caused itching.	1
	+ in general, good compatibility with kit.	ALL

Condition C (n=20)

Categories	Comments	Frequency
Stowage	+ very good stowage -- light and compact.	**ALL**
Odour	+ no problems with new or in-use smell; undergarment did not retain body odour when in use.	**ALL**

Table B-6. Focus Group Comment Summary for Thermal Undergarment Condition D.

Condition D (n=16)

Categories	Comments	Frequency
1) GENERAL COMFORT		
Skin Dryness		
a) wicking effect	+ material is effective in pulling moisture away from the skin.	ALL
b) accumulation of perspiration	+ undergarment became damp during heavy sweating but dried quickly.	ALL
	- undergarment was too warm for heavy work -- this resulted in moisture accumulation in the undergarment.	8
Body Warmth		
a) specific temperatures	- in mild cold conditions the bottoms were too warm.	2
b) specific workloads	- undergarments were effective in all temperatures and workload conditions with the exception of low workloads in extreme cold.	2
	- undergarment was too warm for heavy work -- this resulted in moisture accumulation in the undergarment.	8
Drying Ability		
a) on the body	+ with ventilation, damp undergarment dried quickly.	6
2) DESIGN ISSUES		
General Fit/Function		
a) neck	+ fit of neck was very good.	6
b) cuffs at ankle and wrist	+ cuffs were comfortable.	ALL
	- cuffs at ankle were too narrow and rolled up when socks were pulled on.	1
c) waist elastic	- waist elastic did not stay in place, this caused pressure points.	
	- elastic waistband was not wide enough.	10

Condition D (n=16)

Categories	Comments	Frequency
d) access flap (fly)	- opening was too narrow.	ALL
	+ good overlap of material in genital area; provided extra cold protection.	6
	✸ most participants did not use access flap to urinate.	
Adjustments		
	✸ no comments	
Donning and Doffing		
	+ easy to don and doff.	ALL
3) MATERIAL CHARACTERISTICS		
Feel of the Material		
a) short-term vs. long-term wear	+ material was comfortable.	14
	- itching (no rash), reaction to the material.	2
Durability of the Material		
	✸ some piling after washing, this did not affect performance.	4
	- tearing at the shoulder seam.	1
Washing and Care		
a) washing and drying	- shrinkage after washing and drying.	10
	- **excessive** shrinkage after washing and drying.	3
b) static	- high level of static electricity after undergarment was dried.	ALL
c) repairs	✸ no comments	
4) GENERAL CHARACTERISTICS		
Compatibility		
	+ worked well with other clothing.	ALL
Stowage		
	+ impressed with stowage performance -- compact and light.	ALL
Odour		

Condition D (n=16)

Categories	Comments	Frequency
	+ odour of undergarment was acceptable. + undergarment did not retain body odour.	**ALL**

Table B-5. Focus Group Comment Summary for Thermal Undergarment Condition E.

Condition E (n=18)

Categories	Comments	Frequency
1) GENERAL COMFORT		
Skin Dryness		
a) wicking effect	- undergarment did not effectively wick moisture away from the skin.	8
	+ wicking effect of the undergarment was acceptable. *Note: the focus group participants from week 1 and week 2 were evenly split on this response.*	10
b) accumulation of moisture	- significant accumulation of perspiration in undergarment during heavy work.	8
	+ no accumulation of perspiration in the undergarment.	10
c) workload conditions	- during heavy work, overheating and sweating occurred; the undergarment held moisture and became wet in these conditions.	8
	+ undergarment had acceptable dryness during low to moderate workloads.	ALL
Body Warmth		
a) specific temperatures	+ participants found the undergarment kept them warm in a variety of conditions.	ALL
	- overheating occurred in cold conditions when performing moderate to high workloads.	8
b) specific workloads	+ during low to moderate workloads the undergarment remained dry and kept the participants warm.	ALL
	- the undergarment top was not as warm as the bottoms.	3
Drying Ability		
a) on the body	- the undergarment did not stay dry & did not dry well when worn.	8

Condition E (n=18)

Categories	Comments	Frequency
	+ undergarment stayed dry.	10
b) ventilation	- undergarment took fairly long time to dry by ventilating.	8
	+ undergarment dried quickly by ventilating.	10
2) DESIGN ISSUES		
General Fit/Function		
	- found it very difficult to get a good initial fit with the undergarment; it was often necessary to mix sizes.	8
	- undergarment was not form fitting.	ALL
	- too much material in the seat/rise.	ALL
	- top was too short and would not tuck into bottoms.	15
	- fit was constrictive at the shoulders for all sizes.	2
a) neck	- collar on the neck should be higher.	8
	+ excellent neck features, (i.e., height and zipper).	ALL
b) cuffs at ankle and wrist	- ankle cuff was too tight.	2
	✸ suggested adding a zipper at the ankle cuff for easier access.	
c) waist elastic	- waistband was not strong enough and did not hold pants in place.	ALL
d) access flap (fly)	+ good closure and easy access (most did not use this feature but liked the option of having it).	10
Adjustments		
	- sizes had to be interchanged to achieve a proper fit.	8
Donning and Doffing		
	- bottoms were difficult to don and doff because cuffs were very tight.	10
	+ in general, easy to don and doff.	ALL

Condition E (n=18)

Categories	Comments	Frequency
3) MATERIAL CHARACTERISTICS		
Feel of the Material		
	- chaffing on the inner thigh due to bagginess in the seat.	ALL
	+ overall feel of the material was good -- after initial wash there was some itching at elbows and knees.	2
a) short-term vs. long-term wear	✸ no comments	
Durability of the Material		
	✸ some piling of fabric after the initial wash.	ALL
	- undergarments attracted hair and lint.	2
	- participants expressed concern about the strength and durability of the waistband.	10
	- participants expressed concern that the thin material would wear quickly.	ALL
Washing and Care		
a) washing and drying	+ excellent washing and drying, no shrinkage.	ALL
b) static	+ no noticeable static.	ALL
c) repairs	✸ no comments	
4) GENERAL CHARACTERISTICS		
Compatibility		
	- undergarment did not allow full range of motion when worn with other clothing; the seat was baggy and sagged down.	ALL
Stowage		
	+ very good stowage -- compact and light.	ALL
Odour		
	+ scent at issue was not offensive.	
	+ undergarment did not hold any offensive body odour.	ALL

Table B-7. Focus Group Comment Summary for Thermal Undergarment Condition F.

Condition F (n=21)

Categories	Comments	Frequency
1) COMFORT		
Skin Dryness		
a) accumulation of perspiration	- significant, as soon as the individual began to perspire the undergarment became wet and stayed wet.	All
b) workload conditions	- undergarment only performed well under very low workload where no perspiration occurred.	All
Body Warmth		
a) specific temperatures	+ when the undergarment was not wet, it had very good thermal capability, especially noticeable in extreme cold situations when there was little or no perspiration.	All
	- in most conditions the undergarment did not provide good thermal capability because of the moisture it retained.	All
b) workload conditions	- given the moisture retention problems, the undergarment was too warm for any work other than sentry-type duties.	All
Drying Ability		
a) on the body	- the undergarment had very poor drying ability when next to the skin.	
b) ventilation	- the undergarment dried very slowly, even with ventilation it would not dry out while worn.	All
2) DESIGN ISSUES		
General Fit/Function		
	+ initial fit of the undergarment was good.	11
	- loose and baggy fit in the seat and rise in initial fit.	2
	- undergarment was very bulky when worn with the rest of the kit.	All

Condition F (n=21)

Categories	Comments	Frequency
	- bulkiness of undergarment created folds that caused pressure points.	4
	- undergarment did not retain it's shape and after short duration of wear (approx. 1 hour), the undergarment lost shape and become increasingly baggy, (particularly in the seat). This bulkiness significantly affected range of motion.	All
	- the top of the undergarment did not stay tucked into the bottoms.	
a) neck	- the neck of the undergarment was too open -- it allowed cold air in and body heat out.	All
b) cuffs at ankle and wrist	- the cuffs at all locations were much too long.	All
	- the cuffs were very tight at issue but became baggy after the first wash -- they never returned to their original shape.	All
c) waist elastic	- the waist easily lost elasticity which promoted further sagging of the bottoms.	All
	- waistband was not tight enough	4
d) access flap (fly)	- location was much too low, this could be a function of the increased bagginess of the pants with use.	2
	- would like the access flap to be a little wider.	4
Adjustments		
	- most participants replaced the undergarment with a civilian brand after the first 12-20 hours of use.	10
	- some participants used a thin shirt under the undergarment top to provide a dry layer between the skin and the undergarment. This adjustment helped to keep the clothing layer next to the skin drier while the undergarment top retained most of the moisture.	5
Donning and Doffing		

Condition F (n=21)

Categories	Comments	Frequency
	+ no problems with donning or doffing.	20
	- some found the bottoms difficult to remove because of the tightness of the cuffs at issue.	2
3) MATERIAL CHARACTERISTICS		
Feel of the Material		
a) general	+ material was comfortable, no problems.	All
b) short-term vs. long-term wear	- material became itchy after long-term wear.	1
Durability Of The Material		
	- stitching at the seams of the cuffs came loose and let go at all four locations.	8
	- bottom of the undergarment top became very baggy and lost shape.	4
	- seams along the arm came apart.	1
	- fabric wore thin at the knees and elbows.	All
	- material lost elasticity after first wash.	All
Washing and Care		
a) washing and drying	- severe shrinkage after the first wash -- undergarment returned to original shape with wear.	All
	- the undergarment took an extremely long time to dry.	
	- there was a significant loss of elasticity throughout the undergarment after the initial and subsequent washing and drying cycles. Undergarment became very baggy and lost shape.	
b) static	+ no significant static	
c) repairs	✸ no repairs were performed by the soldiers	
4) GENERAL CHARACTERISTICS		
Compatibility		
	- the undergarment was not comfortable	All

Condition F (n=21)

Categories	Comments	Frequency
	under the regular kit -- very bulky -- limited range of motion for activities requiring bending and significant movement.	
	- the undergarment did not stay in place -- it caused pressure points when worn with other clothing.	1
	- the undergarment did not stay tucked into combat boots because of the loose fit at the cuffs.	1
Stowage		
	- the undergarment was very bulky and took up too much space -- most soldiers elected not to bring it on the field exercise.	20
	+ the undergarment was compact enough to pack and carry.	1
Odour		
	+ the new smell of the undergarment was acceptable.	20
	- the new smell of the undergarment was bothersome, but fine after the first wash.	1
	- the undergarment retained a body odour smell after long-term wear. This smell was still present after washing.	All

APPENDIX C

REQUIREMENT VERIFICATION MATRIX (RVM) FOR THERMAL UNDERWEAR

Table C-1. Focus Group Summary Categories and Topics in Reference to the DCIEM Requirement Verification Matrix - Thermal Underwear.

Focus Group Summary Table Category	RVM SOR Reference Number
1) GENERAL COMFORT	
Skin Dryness	(4.4.1.1 and 4.4.4.6)
a) accumulation of perspiration	
b) workload conditions	
Body Warmth	(4.4.1.2)
a) specific temperatures	
b) workload conditions	
Drying Ability	(4.4.1.2)
a) on the body	
b) ventilation	
2) DESIGN ISSUES	
General Fit/Function/Function	(4.4.4.1, 4.4.4.2 and 4.4.4.7.1.4)
a) neck	
b) cuffs at ankle and wrist	
c) waist elastic	
d) access fly	
Adjustments	
Donning and Doffing	(4.4.4.5)
3) MATERIAL CHARACTERISTICS	
Feel of the Material	(4.4.4.2 and 4.4.2.4)
a) general	
b) short-term vs. long-term wear	(4.4.2.1, 4.4.2.4 and 4.4.4.4)
Durability of the Material	(4.4.2.3)
Washing and Care	(4.4.2.7 and 4.4.2.2)
a) washing and drying	(4.4.2.2 and 4.4.3.3)
b) static	(4.4.2.8)
c) repairs	(4.4.3.1)
4) GENERAL CHARACTERISTICS	
Compatibility	(4.4.4.3)
Stowage	(4.4.2.6)
Odour	(4.4.2.11)

APPENDIX D

Specifications for the LWTU

Table D-1. Specifications for the LWTU.

Feature	*Specification*	*Comments*
Material		
	Should not suffer noticeable shrinkage after multiple wash and dry cycles -	Type B, E and F suffered significant to severe shrinkage after one to several wash/dry cycles
	Should not stretch out of shape enough to significantly affect fit or thin at the knees and elbows.	e.g. type A showed excessive thinning at knees and elbows. Other types had elasticized wrist and ankle bands at the cuff. Participants felt that types B and D were too thin and may be prone to tearing and wearing. However, no noticeable wear was detected.
	Should not pile (fibers form balls on the surface of the material) - should maintain its texture and look	The wool types (C and D) both showed considerable piling at the wrists and ankles, as well as the rest of the garment, although to a lesser degree.
	Should not cause excessive overheating in high workloads	Types B, D, and F caused excessive heat buildup during high workload, A and F retaining moisture and causing wearer to chill when activity stopped. Type E's bottoms were too hot in mild conditions during low to medium activity.
	Should provide effective insulation. Types B, C, D and E provided warmth even in extremely low temperatures	Types A and F failed to provide warmth at extremely low temperatures, particularly in windy conditions.

Table 4-1. Specifications for the LWTU (continued).

Feature	*Specification*	*Comments*
	Should not irritate the skin under all workload conditions.	Types C and D caused some participants minor itching when performing heavy workload tasks, and material became wet. Considering these were wool, the irritation was very minor. Type B caused some minor irritation after long term wear.
	Should transfer (wick) the moisture away from the skin and to the outer surface of the material. NOTE: Materials, which seem to do this well are the Thermastat Polyester, Wool/Polyester blend with Thermax inner layer and the Coolmax material.	Types A, D and F absorbed the moisture until saturated, then allowed the moisture to remain in contact with the skin. Types B, C and E effectively kept the moisture away from the skin even under heavy workload conditions.
	Should prevent static charge buildup when dried in a drier.	Most of the prototypes (A, B, C, and E) contained considerable static after removal from the drier. Only the in-service (F) and Type D did not produce appreciable static charges.
	Should have reinforced seams.	Types A and F had poor seams, resulting in stitching coming apart and seams partially gaping or showing thin spots.
	Should dry quickly, allowing moisture to evaporate rapidly. Type A, B, E dried very quickly when hung to dry, and just slightly longer when ventilated while worn.	Types C and D took longer to dry, but did achieve a dry state after about 30 minutes hanging at room temperature. Type F took many times longer to dry than all of the other types.
	If material is wool, an inner layer of material that promotes wicking is necessary to keep moisture from the skin	Condition D (two layers) performed better at keeping the participants dry than condition C (one layer)
	Should not possess a strong odour when new, nor produce a strong odour when worn, nor retain body odour when worn.	Condition A retained body odour when worn for an extended period of time (about 6 days)
TOP		
Neck	Alternative design - high neck (turtleneck) with slide fastener - this was a very popular suggested design feature. Type D had such a design (but only a	Ensure that the neck is snug, but not tight (should not bag after wear) Present mock turtleneck with slide

Table 4-1. Specifications for the LWTU (continued).

Feature	*Specification*	*Comments*
	mock turtleneck) and participants indicated a higher neck would be desirable for thermal protection adjustability	fastener (D) was not high enough to permit full coverage of the neck and underside of chin
	Band should be wide if a crew neck is used	Narrow bands were generally disliked and claimed to be uncomfortable
	Opening should be fairly tight if a crew neck is used (as in condition E)	
Trunk Length	The length of the top should be long enough to tuck into the bottoms or outer pants, such that bending over does not result in separation between top and bottom - but not too long (A, B and C had acceptable lengths)..	Many participants found that the top in prototypes B, E and F, shrunk after each wash and did not allow enough length to tuck into pants. F's top length was too short. Type C's was considered acceptable for length by most, yet all participants felt that it would not stay tucked in.
	A scoop back design would provide effective coverage at the back (given sufficient trunk length) with reduced bulk of material at the front.	
Wrist Band	Cuffs should be elasticized (ribbed).	Type B had a turned-in cuff without elastic, resulting in bagging and poor fit at the wrists and ankles.
	Elastic must be durable and maintain tensile strength even after many wash/dry cycles	Types F did not maintain strength and began to bag and loose shape, riding up the arm. Type A suffered several instances where the elastic broke down and tears appeared in the cuffs of the top and bottoms.
	Elastic must give enough to allow easy access.	Type D did not give enough to allow easy access, but was comfortable and durable.
Shoulder	A set-in arm/shoulder design should be used.	All of the conditions had set-in arm/shoulder designs and showed full acceptance in terms of comfort, durability and function. No raglan sleeve was evaluated.
Bottoms		
Waistband	Elastic must be durable and not breakdown with washing and drying.	Types A, C, D and F were too easily broken down after several washings

Table 4-1. Specifications for the LWTU (continued).

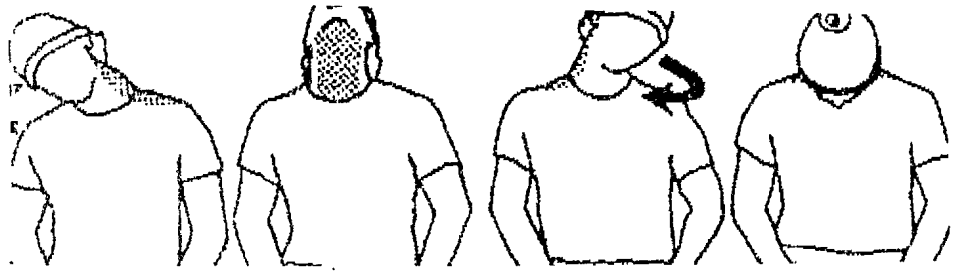
Feature	*Specification*	*Comments*
	Types B and E stood up better than the others did.	
	Covering on waistband should be made with a material, which does not cause irritation to skin.	The wool blend prototypes (C and D) caused some irritation for many participants.
	Waistband should be broad enough to prevent cutting into skin.	Type A and E were too narrow, and were uncomfortable, due to pressure on skin.
	Use an elastic that has slightly more tension than the present prototypes (e.g. type B seems to have the right amount)	Most (5 out of 6) of the prototypes had waistbands which were too loose
Crotch Length	The crotch length of the laundered bottoms should not hang, bag or bunch up under overgarments.	Types A and F suffered from all of these problems, and type D had some hanging and bunching in the crotch.
	Distance in rise should be designed to provide reasonably snug fit with consideration of both stretchability of fabric and local mobility requirements. There seems to be a tendency to provide excessive material in this area, likely to improve mobility; however, the excess material is uncomfortable and when layered with other clothing can lead to potential loss of mobility.	Types A and F had rises, which were too long.
Access Flap	The access flap must be long enough to allow easy entry of hand, and it should be designed to allow both complete closure with enough overlap to provide adequate insulation, but also allow access.	Types A and D had easy access, though D had better insulating characteristics. Type E had very good overlap and provided better insulation. Most of the participants said they did not use the fly, preferring to pull their layers of clothing down at the front.
Stowage		
	The garment should be light-weight and compressible.	All of the prototypes (conditions A to E) were light-weight, and compressible

RANGE OF MOTION EXERCISES

THE LIGHTWEIGHT THERMAL UNDERGARMENT RANGE OF MOTION TESTS

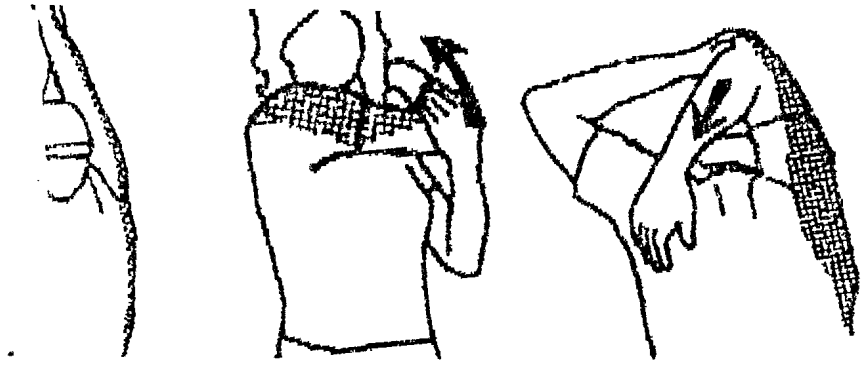
Participants engaged in the following range of motion exercises to determine if the underwear restricted any movements:

Exercise 1



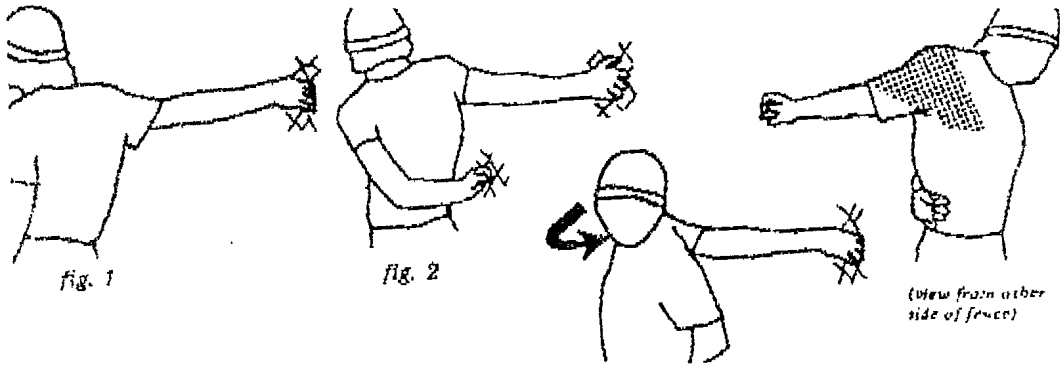
Neck area of LWTU

Exercise 2



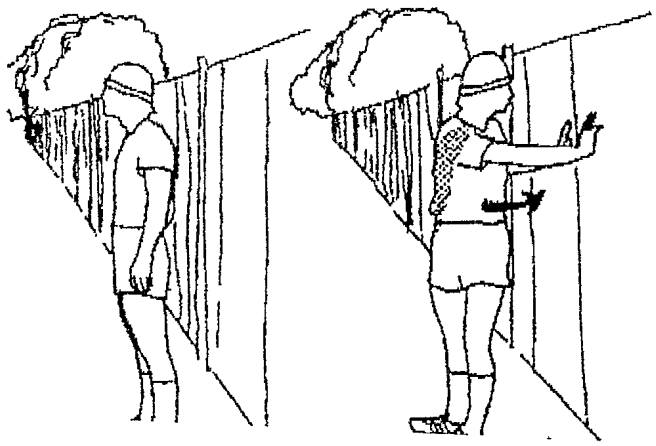
Shoulder/Upper arm area

Exercise 3



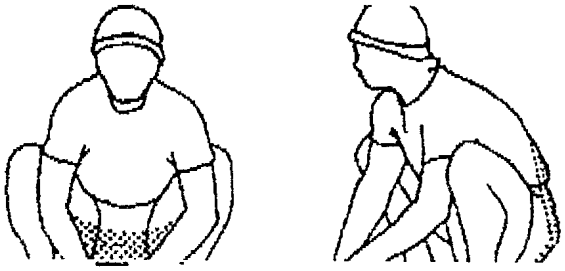
Shoulder Area

Exercise 4



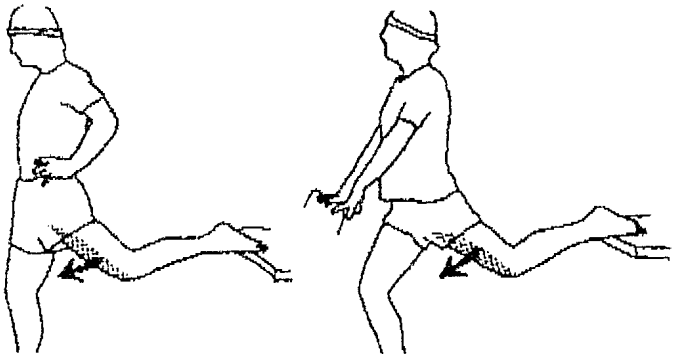
Back area (left/right side)

Exercise 5



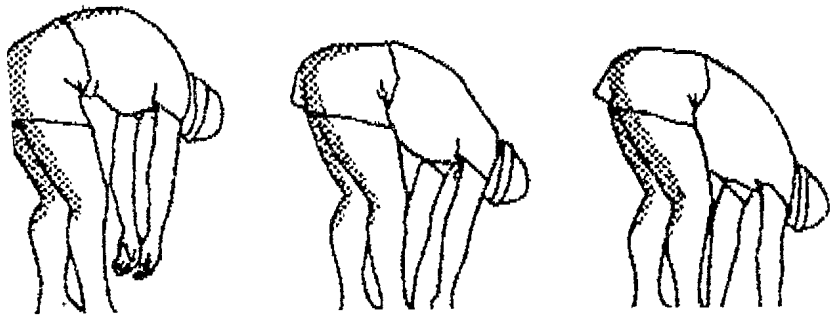
Groin/Upper thigh area

Exercise 6



Upper thigh area

Exercise 7



Back of thigh and lower back

#506725